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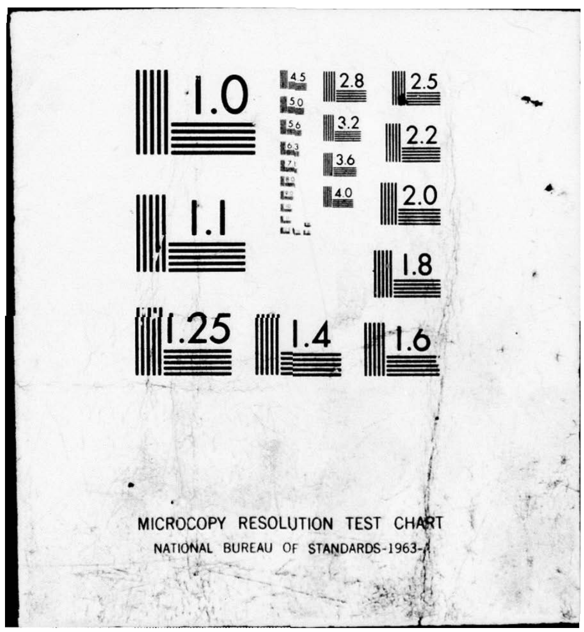
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OT REPORT 77-134

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

A FORTRAN computer program, entitled PRED77, has been prepared to predict SHF microwave link degradation due to rain-caused attenuation in the United States of America. This program, which predicts 5, 50, and 95 percent confidence levels of rain-caused attenuation, is similar to one developed earlier for Europe. Major changes are in the prediction of rain rate climatology.

A telecommunications-oriented rainfall climatological index is developed for the U.S.A., and 19 zones of similar rainfall characteristics are subsequently developed, using a 359-station data base. Contour maps of important input parameters that can be used to assess rain rate and its variance at a location via numerical methods in PRED77 are presented. These numerical methods are also discussed, as well as the limitations of these methods for large variances of the input parameters. (Abstract continued on reverse).

16. Key Words *(Alphabetical order, separated by semicolons)*

Microwave rainfall attenuation; rain rate prediction; terrestrial links; United States climatology.

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ABSTRACT (continued)

As in earlier work for Europe, an interpolation scheme for obtaining otherwise unknown data at a location from the 359-station data base is included in PRED77. The interpolation error created by this process is estimated, and the pitfalls of the whole estimation procedure by interpolation are discussed The interpolation error made in estimating an input variable is included in the variance estimation of that variable where feasible.

The mechanics of the program PRED77 are discussed, and the program is listed and flow diagrammed in the Appendices.

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PREFACE

The research conducted at the Institute for Telecommunication Sciences and reported in this paper was supported by the United States Army Communications Electronics Engineering-Installation Agency (USACEEIA), Ft. Huachuca, AZ, 85613, on Project Order No. CC-033-76.

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PRECIPITATION VARIABILITY IN THE U.S.A. FOR MICROWAVE TERRESTRIAL SYSTEM DESIGN

E. J. Dutton*

A FORTRAN computer program, entitled PRED77, has been prepared to predict SHF microwave link degradation due to rain-caused attenuation in the United States of America. This program, which predicts 5, 50, and 95 percent confidence levels of rain-caused attenuation, is similar to one developed earlier for Europe. Major changes are in the prediction of rain rate climatology.

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As in earlier work for Europe, an interpolation scheme for obtaining otherwise unknown data at a location from the 359-station data base is included in PRED77. The interpolation error created by this process is estimated, and the pitfalls of the whole estimation procedure by interpolation are discussed The interpolation error made in estimating an input variable is included in the variance estimation of that variable where feasible.

The mechanics of the program PRED77 are discussed, and the program is listed and flow diagrammed in the Appendices.

Key Words: Microwave rainfall attenuation, Rain rate prediction, Terrestrial links, United States Climatology.

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*The author is with the Institute for Telecommunication Sciences, Office of Telecommunications, U. S. Department of Commerce, Boulder, CO, 80302.

1. INTRODUCTION AND BACKGROUND

This report is concerned with the prediction of rain rates in the United States of America for communications purposes. This is because planning and engineering of new microwave terrestrial links in the U.S.A. requires extensive pre-examination of their potential for interference and degradation. This is a result of heavy utilization of the SHF spectrum, causing appreciable demand for the spectrum. Rainfall is known to have significant bandwidth (Ma and Dougherty, 1976), attenuation (Dutton, 1968), phase delay (Zuffery, 1972), interference (Hubbard, et al., 1973), and depolarization (Thomas, 1971) inpact on microwave terrestrial links. Thus the investigation of rainfall parameters as they influence the performance of terrestrial links at SHF (and beyond) in the United States, including Alaska and Hawaii, is essential to adequate system protection design.

Rainfall is the topic of concern in this report because it has been assumed that standard siting procedures have been followed in designing a terrestrial link. This includes standard adequate combinations of antenna-tower height and link path lengths chosen so as to insure that the individual link propagation paths are line of sight. Further it has been assumed that performance degradation due to terrain and atmospheric multipath will be minimized, where necessary, by the standard remedial techniques of space and/or frequency diversity. The computer program PRED77, described in Section 5, therefore, treats only rainfall effects on microwave links operating at frequency in the 3 to 30 GHz (SHF) range. The program is applicable to terrestrial links rather than air/ground or satellite/ground links, and is further applicable to only the U.S.A., including Alaska and Hawaii. The program output of predicted link attenuation and its 5 and 95 percent confidence limits for given percents of a year include effects of oxygen absorption, water vapor absorption, cloud and rain attenuation. The behavior of microwave links in the presence of oxygen and water vapor absorption at SHF is not expected to be an area of concern, because the effects are minor compared to those of rain, and they are much more readily predictable.

Traditionally, the performance of microwave links in the presence of inclement weather has been related to the rain rate, R_o, observed at the earth's surface (Ryde, 1946, Barsis et al., 1973). The rain rate, R_o, is usually distinguished as a "point" rain rate. The conversion of R_o to a "path average" rain rate is essential in the prediction of path performance. This problem is not, however, the immediate concern of this report. It, and the subject of path performance, were treated in the Office of Telecommunications Technical Memorandum, OTM 76-225, (a memorandum of limited distribution) entitled "Computer Software for FWCS Performance Prediction dated August, 1976. Requests for information on this document should be made to the author at the address shown on page 1. Therein is described a FORTRAN computer program PREDIC, which incorporated subroutines containing specific methodology for prediction of R_o. This rainrate prediction is accomplished by estimating the distribution of the mean rain rate, $\bar{R}_o$, for a given location, and the variance, $S^2_{R_o}$, of R_o at the percentile on the distribution of interest (Dutton, 1977). From these, the 5 and 95 percent confidence bands for the entire distribution are obtainable, using the distributions discussed in Section 3.2.

A procedure for evaluation of $\bar{R}_o$, and $S^2_{R_o}$, as developed in Dutton (1977) and Dutton et al. (1974) is called the "modified R-H model". The reason for this nomenclature is that the procedure represents a rather extensive modification of the original Rice and Holmberg (1973) model (R-H model)--a modification for which some price in precision has had to be paid, as discussed in Section 3.1. The OTM 76-225, mentioned above, discusses four separate procedures whereby the output of the modified R-H model (i.e. subroutine DELTT) is used to predict atmospheric attenuation and its 5 and 95 percent confidence limits on a European microwave link. For purposes of this report, it is important for the reader to note at this point that prediction procedure other than rain rate prediction is assumed basically unchanged (except for some minor modifications described in Section 5.0) from the European development, when applied to the U.S.A.* Hence, this report is devoted in its entirety to improving rain rate prediction procedures for the U.S.A. over those used for the European study.

2. COMMUNICATIONS-ORIENTED CLIMATOLOGY OF THE U.S.A.

Since the turn of the century (Koppen, 1900; Thornthwaite, 1931), the agrarian influence has dominated worldwide climatological thinking especially, in the conterminous U.S.A. It has been amply indicated in recent years, however (CCIR, 1972), that telecommunications has its own set of climatological needs, not necessarily compatible with those of other areas of interest such as agriculture. For this reason, it was felt that climates in the U.S.A. should be categorized from a telecommunications point of view, rather than from the traditional, agricultural standpoint, as had been done previously for Europe (Dutton et al., 1974). A natural starting point for this reclassification seemed to be the R-H and modified R-H models for rain rate prediction. This was because they represent models of a meteorological parameter, rain rate, that were developed strictly for telecommunications applications.

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*As used here and thereafter, the "U.S.A" includes Alaska and Hawaii; the "conterminous U.S.A." does not.

Two important parameters in the R-H or the modified R-H model are M, the average annual precipitation at a location of interest, and β, the ratio of the precipitation associated with thunderstorms to the total precipitation of an average year*. Thornthwaite (1931) defined what is known as the "P-E Index" for specific use in the rainfall climatological characterization of the conterminous U.S.A. for agriculture purposes. This index, which is directly related to the precipitation to evaporation ratio of a given location, is capable of giving a macroscale (or large-scale) estimate of climatic behavior. In analogy with the "P-E index," therefore, it was decided to use an "M/β Index," the ratio of M to β, to estimate macroscale rainfall climatological behavior for telecommunications purposes. This is because the two main elements of rainstorms--stratiform and convective storms--that affect microwave telecommunications are described by the parameters M and β. Hence, roughly, a large M/β indicates a climate with mostly stratiform tendencies, whereas a small M/β indicates a climate with mostly convective tendencies. Figure 1 shows the boundaries of the 19 rainfall zones of approximately constant M/β that resulted from the M/β index determined from the 305 first-order U.S. Weather Service observing stations (NOAA, 1975). The locations of the stations used for the data analysis in this report are shown in figure 2. It should be recognized that a simple ratio such as M/β, although it relies strictly on telecommunications-oriented parameters, can still only serve as a guide rather than an absolute, in drawing boundaries such as in figure 1. Otherwise, nineteen such zones would have never resulted. The unique climatological features of one part of the U.S.A. as opposed to another part must be taken into account, even though both parts might have similar M/β values. Hence, older climatological characterizations

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*Note that β is a parameter derived from other input data, as discussed in Dutton (1977).

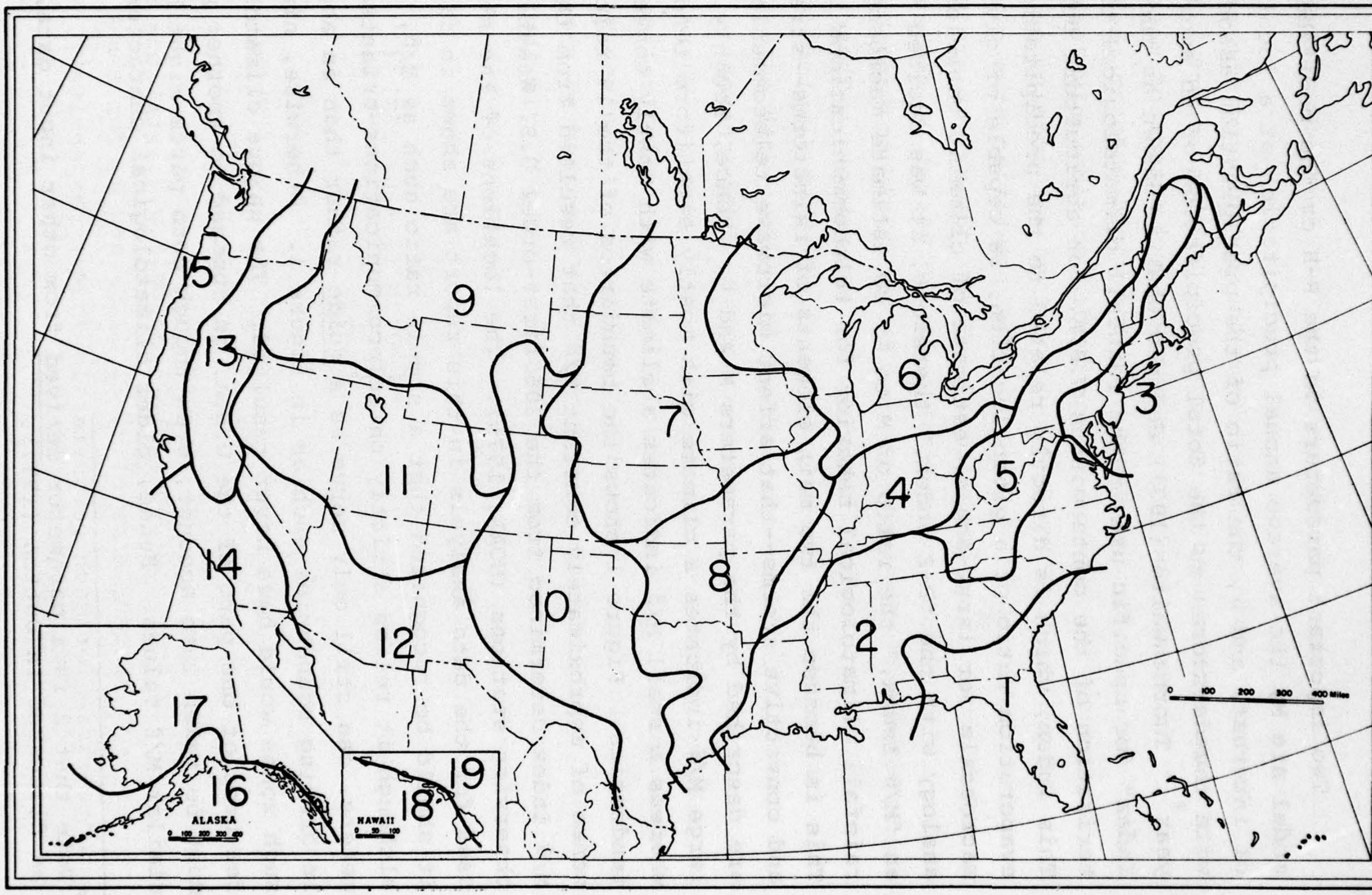

Figure 1. Rainfall Climatic Zones in the U.S.A.

of the U.S.A. are not without virtue, and must, still be included.

Figure 2, as mentioned, shows the location of the principal data points used in the analysis in this report. To the author's knowledge, no greater variety and extent of meteorological data are taken anywhere in the world than at these 305 stations. In many cases worldwide, considerably less data are available. The R-H and modified R-H models, as discussed in Dutton (1977), require four quantities at a given (U.S.A.) location as basic input. These quantities are M; M_m, the greatest monthly precipitation in 30 years; D, the average annual number of days with precipitation $\geq$0.25 mm; and U, the average annual number of days with thunderstorms. These are available at the 305 first-order U. S. Weather Service (U.S.W.S.) stations (NOAA, 1975). Additional locations (with only some of the four input quantities available) of importance to U.S. Army communications users, are shown in figure 3. Therein are represented 54 U.S. Army Airfield (AAF) meteorological data recording sites, as reported by the U.S. Naval Weather Service (USNWS, 1969-70). Values of M and U are recorded at these sites, but it was necessary to estimate D and M_m via the contour maps discussed next. The thunderstorm ratio, β, can be obtained from these other input variables via

$$\beta = \beta_o \left\{ 0.25 + 2 \exp \left[\frac{-0.35\ (1 + 0.125M)}{U} \right] \right\}, \quad (1)$$

where

$$\beta_o = 0.03 + 0.97 \exp\ [-5 \exp(-0.004M_m)]\ . \quad (2)$$

The data from the 305 first-order U.S.W.S. stations were used to draw contour maps of M, β, D, U, and M_m for the U.S.A. A contour map for each parameter is shown, respectively, in

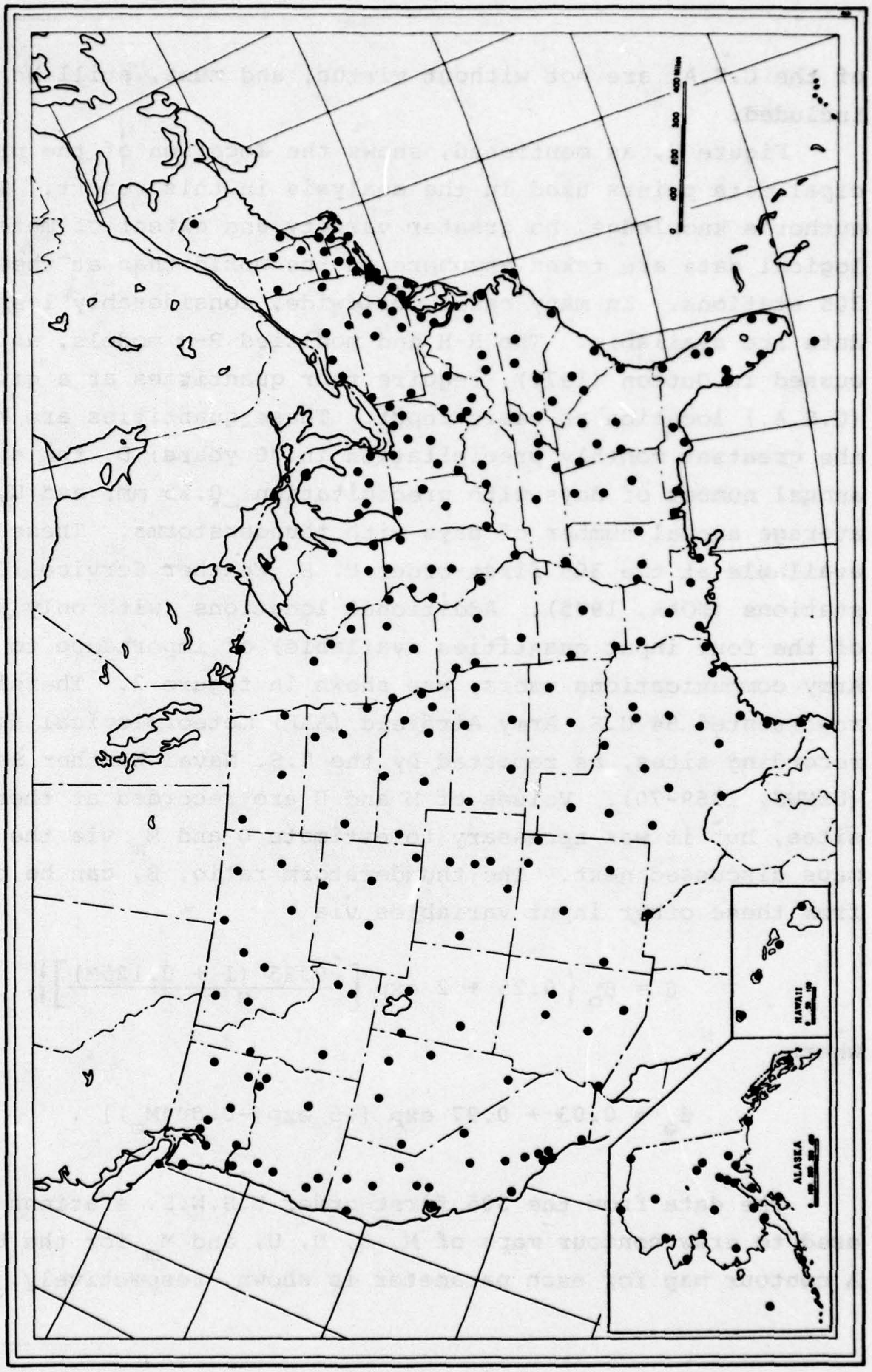

Figure 2. Location of 305 first-order U.S. Weather Service Stations in the U.S.A.

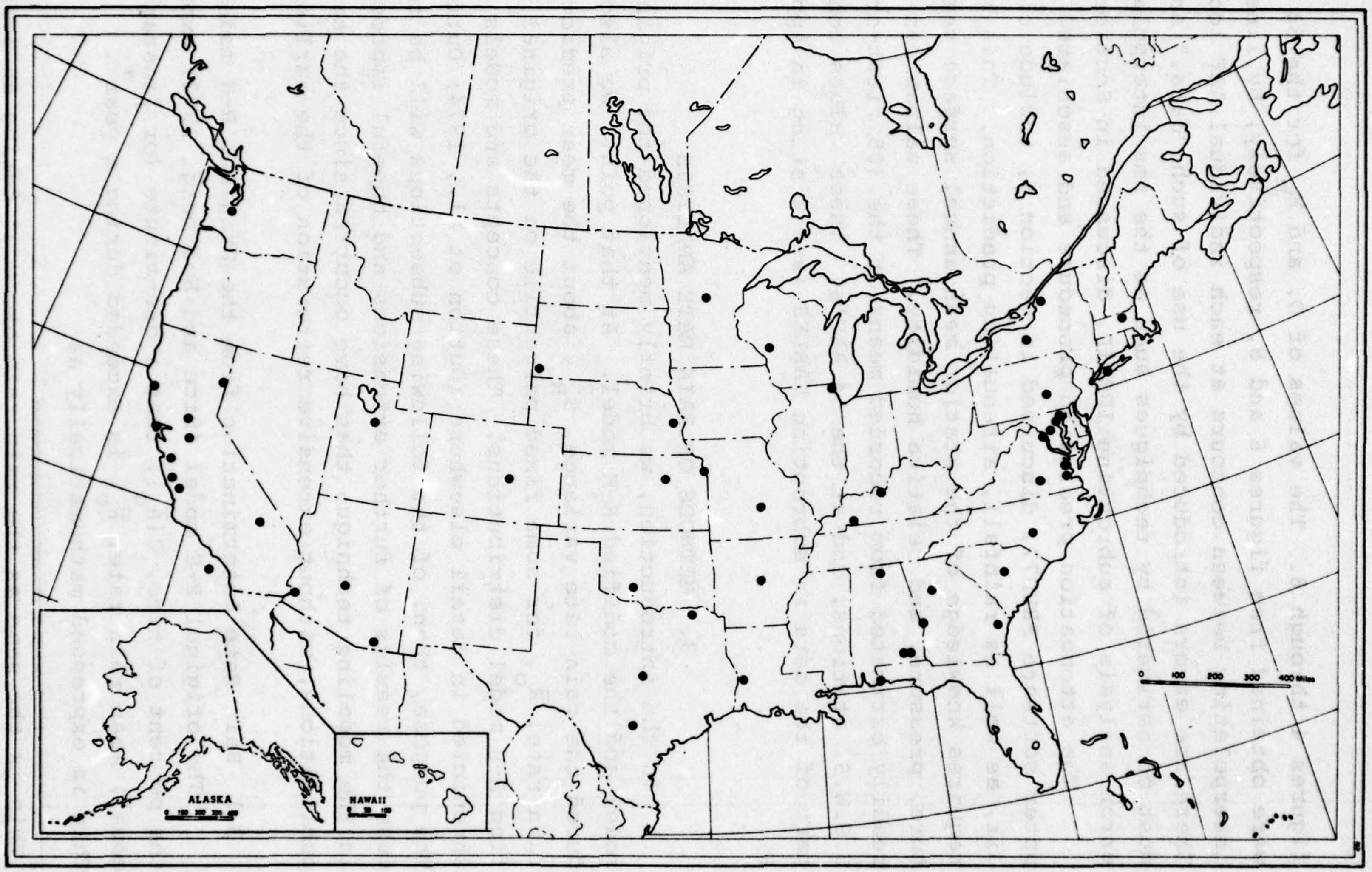

Figure 3. Location of 54 U.S. Army Air Fields with extensive meteorological data records in the U.S.A.

figures 4 through 8. The values of D, and M_m for the 54 AAF's were obtained from figures 6 and 8, respectively, by linearly interpolating between contours at each individual AAF location. There are errors introduced by the use of such "data," and they must be estimated by techniques such as the rms interpolation error analysis of subroutine IDBVIP, discussed in Section 4.

The attenuation prediction procedure and associated computer software PRED77, discussed in Section 5, include clear-air, as well as rainfall, attenuation prediction. This prediction requires knowledge of the station mean annual surface temperature, pressure, and relative humidity. These values can be readily estimated from recorded means at the 305 first-order U.S.W.S. stations, and at the 54 AAF's. These values constitute part of the data in subroutine TABLES (see listing in Appendix B).

3. METHODS OF RAIN RATE ANALYSIS

In the introduction, we briefly mentioned the original R-H model and the modified R-H model. At that point, we also introduced the rain-rate variance, $S^2_{R_o}$, about the mean predicted rain rate, $\overline{R}_o$, for some fixed percentile on the original or modified R-H model distributions. These concepts and models are chronicled in detail elsewhere (Dutton et al., 1974; Dutton, 1977). The purpose, then, of the following subsections will be to discuss the results of further extensions and hopeful improvements in the modeling technique that have occurred since the earlier publications, without extensive reiteration of the earlier work.

3.1 Rain Rate Determination from the Original R-H model

The original R-H model (Rice and Holmberg, 1973) expresses the percent of time, $P(\overline{R}_o)$, that a one-minute (or "instantaeous") mean rain rate, $\overline{R}_o$, is exceeded during a year*. This is expressed mathematically as

*This is the same as the rain rate exceeded during an <u>average</u> year.

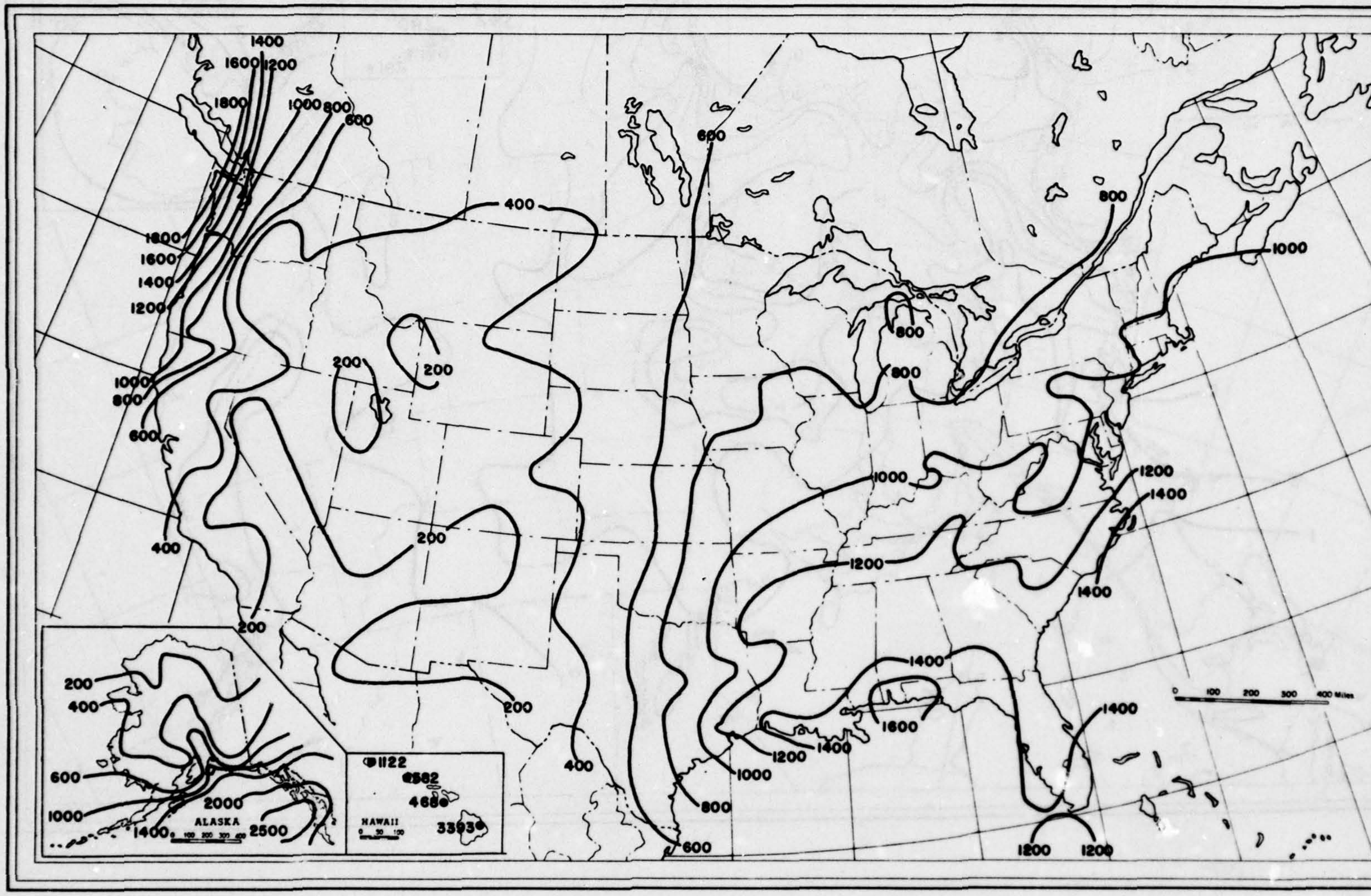

Figure 4. 30-year mean annual precipitation M, in millimeters, for the U.S.A.

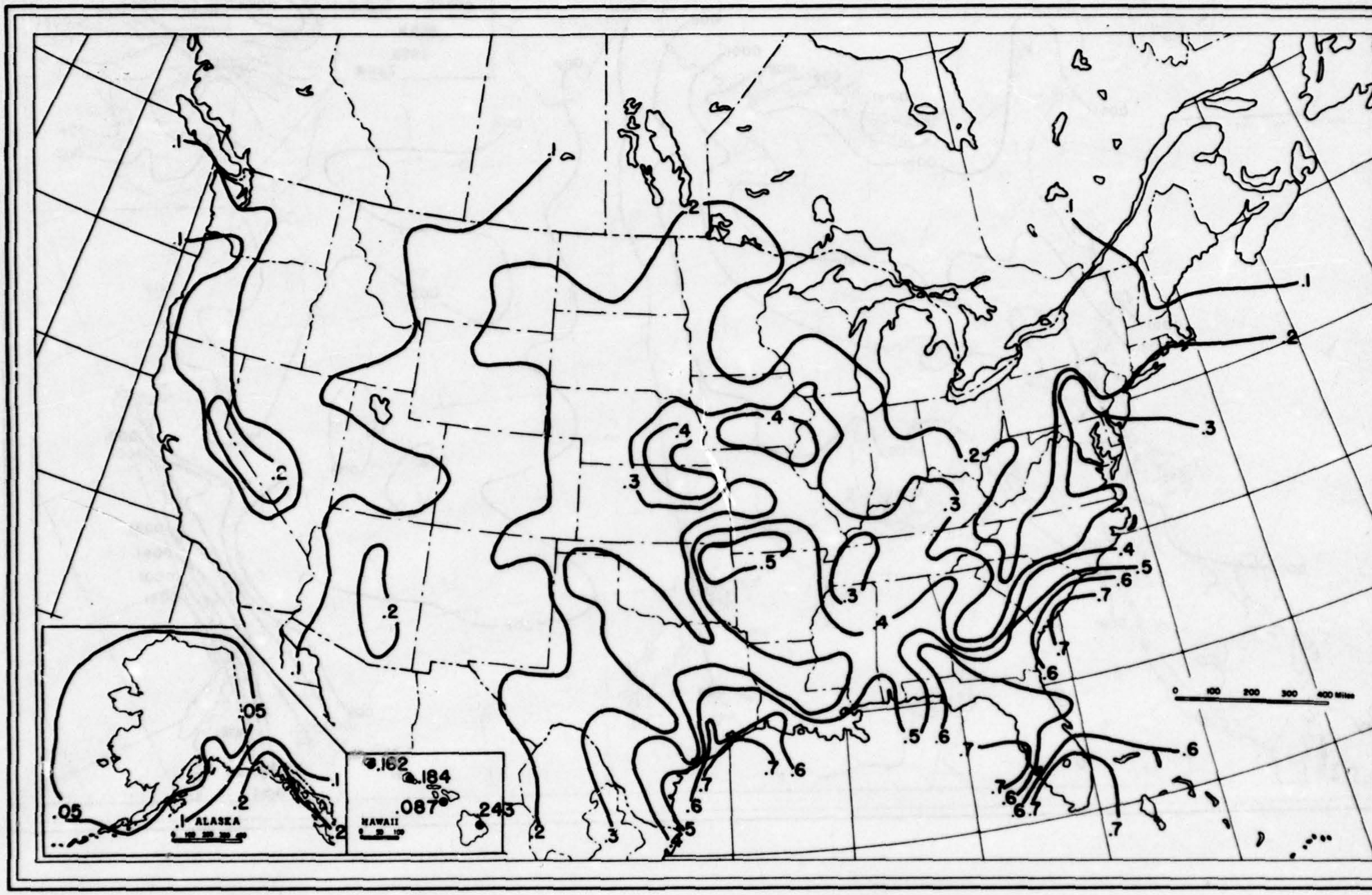

Figure 5. Mean annual thunderstorm ratio, β, for the U.S.A.

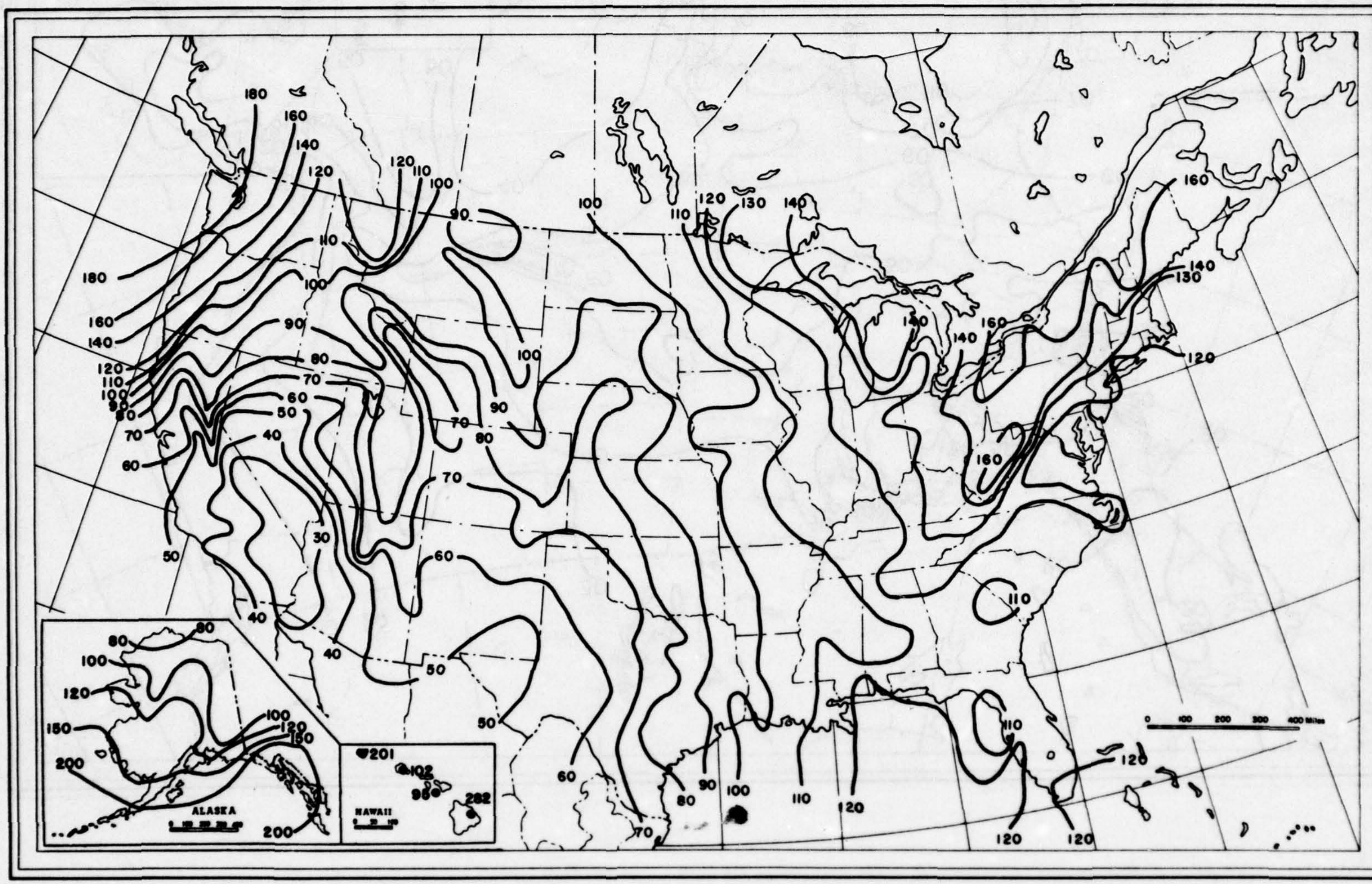

Figure 6. 30-year mean annual number of days, D, with precipitation greater than 0.25 mm for the U.S.A.

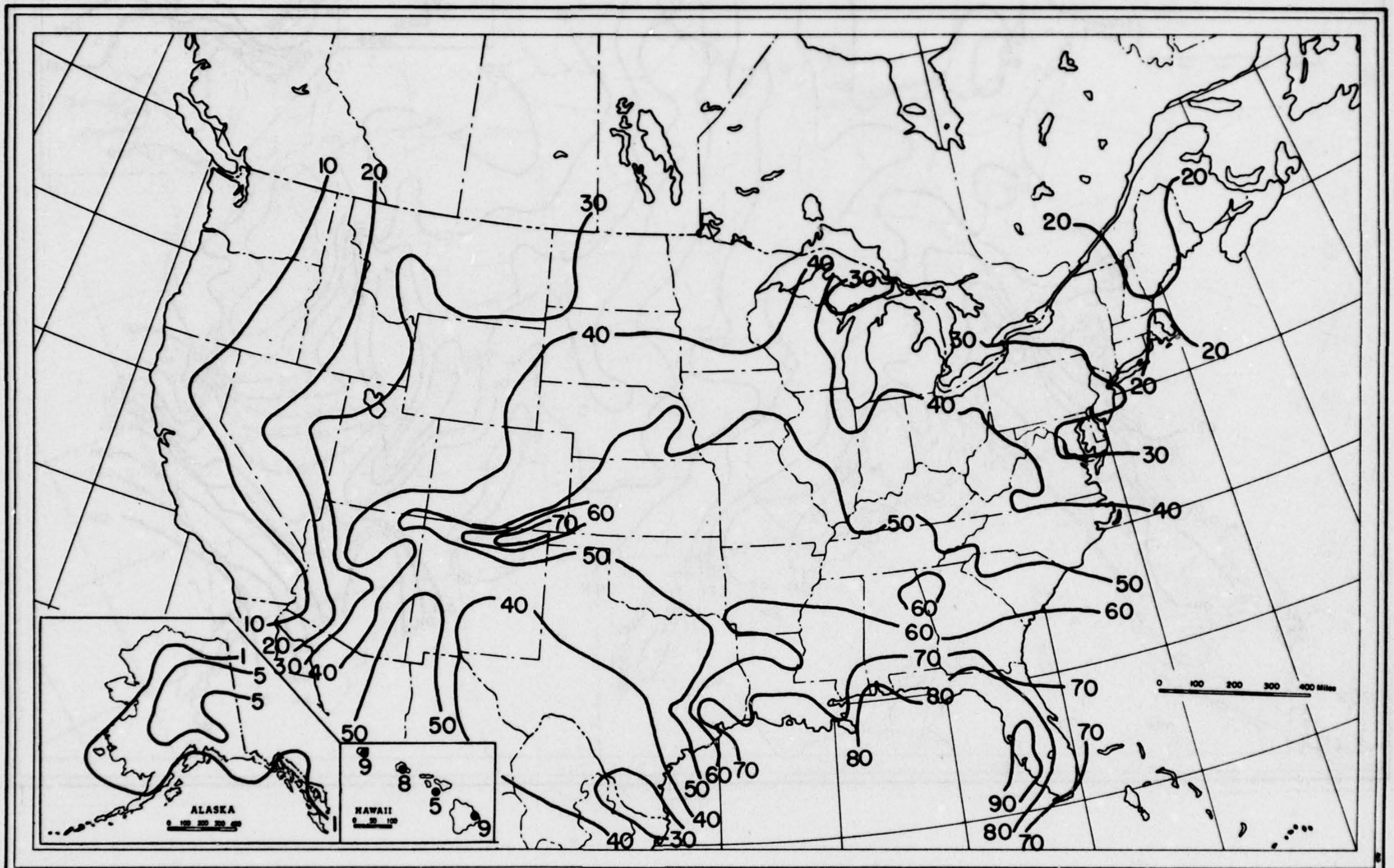

Figure 7. 30-year mean annual days, U, with thunderstorms for the U.S.A.

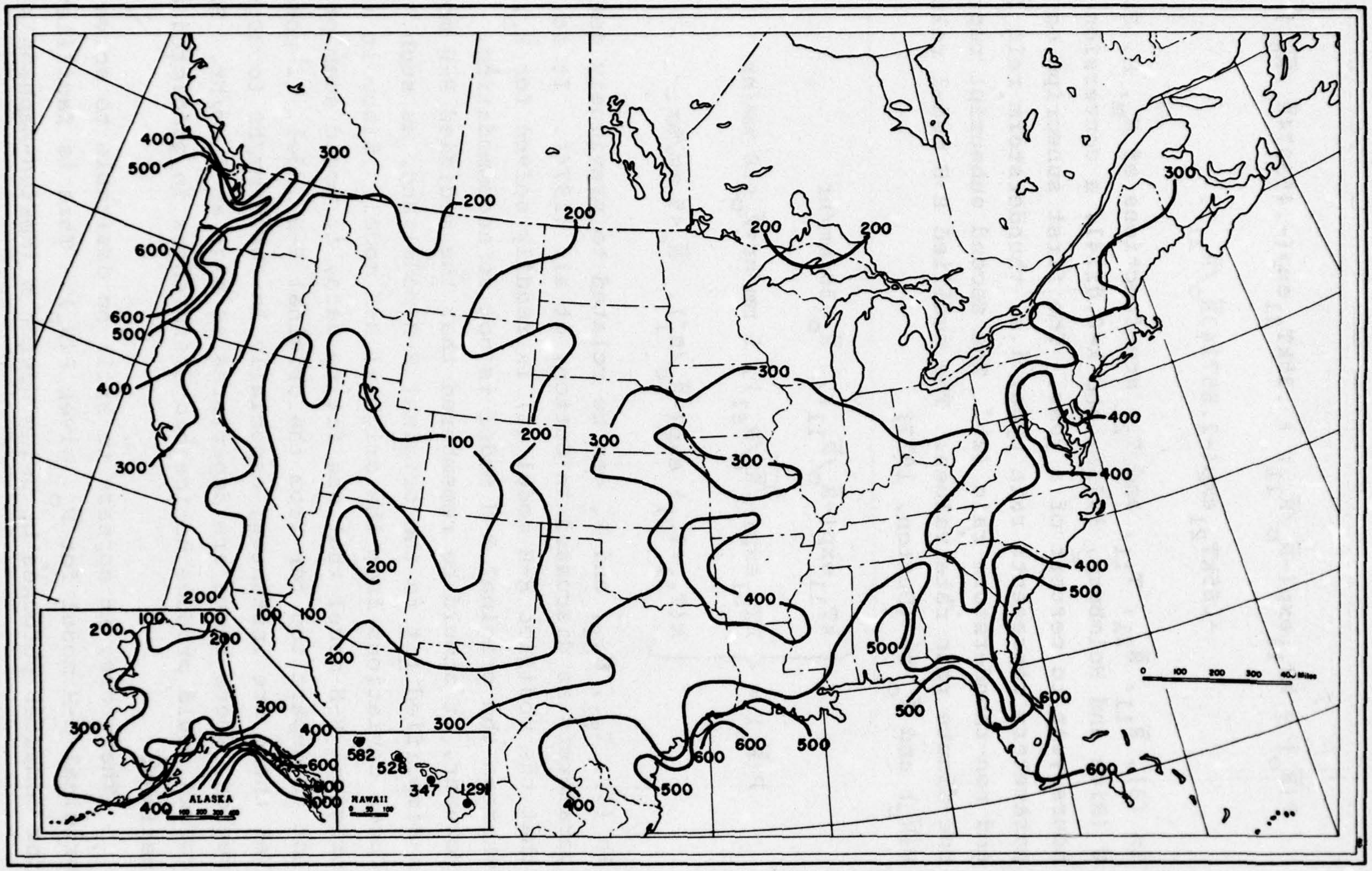

Figure 8. Maximum monthly precipitation M_m, in millimeters, for the 30-year period 1941 through 1970.

$$P(\bar{R}_o) = kT_{11}\exp(-\bar{R}_o/\bar{R}_{11}) + .35kT_{21}\exp(-.453074\bar{R}_o/\bar{R}_{21})$$

$$+.65kT_{21}\exp(-2.857143\bar{R}_o/\bar{R}_{21}). \qquad (3)$$

In (3), $\bar{R}_{11}$, $\bar{R}_{21}$, T_{11}, and T_{21} are functions of M_m, M, D, and U (Rice and Holmberg, 1973), and k=0.01141, a conversion from hours/year to percent of a year. The first subscript on these parameters represents rain type; i.e. thunderstorm rain (1) and non-thunderstorm rain (2). The second subscript represents one-minute rain rate values. The modified R-H model relates $P(\bar{R}_o)$ and $\bar{R}_o$ by (Dutton, 1977)

$$P(\bar{R}_o) = \begin{cases} kT_{11}\exp(-\bar{R}_o/\bar{R}_{11}), & \bar{R}_o > 30 \text{ mm/hr} \\ kT_{S1}\exp(-\sqrt[4]{\bar{R}_o}/R_{S1}), & 5 \text{ mm/hr} \le \bar{R}_o \le 30 \text{ mm/hr} \\ k(T_{11}+T_{21})\exp(-\bar{R}_o/R_1'), & \bar{R}_o < 5 \text{ mm/hr}. \end{cases} \qquad (4)$$

In (4), T_{S1}, R_{S1}, and R_1' can be related to previously defined parameters as discussed in Dutton, et al. (1974). It is clear that the modified R-H model (4) is readily solved for $\bar{R}_o$, whereas the original R-H model is not so accommodating. However, it should be remembered that the modified R-H model is a simplified fit to the original R-H model and, as such, introduces deviations from the original R-H model. Since it is the original R-H model that was fit to data, it would seem prudent not to depart too far from the original R-H model, if possible. Yet there are instances, especially in the 5 mm/hr to 30 mm/hr region, where there are departures as high as 8 mm/hr. Such values could produce noticeable differences in predicted attenuations.

Therefore, it appears to still be desirable to solve the original R-H model for $\bar{R}_o$, given $P(\bar{R}_o)$. This is facilitated for computer purposes by using Newton's (Newton-Raphson's) method (Sokolnikoff and Sokolnikoff, 1941; Dahlquist et al., 1974). For any given rain rate, R, we can define an f(R) such that

$$f(R) = P(\bar{R}_o) - g(R) \quad , \qquad (5)$$

where g(R) is the right-hand side of equation (3) when R is substituted for $\bar{R}_o$. Furthermore

$$R = \bar{R}_o$$

is the only root of f(R), because (5) is a single-valued, continuous function. We can therefore use Newton's method to obtain any degree of accuracy desired (Sokolnikoff and Sokolnikoff, 1941). Hence, having chosen an <u>appropriate</u> <u>first</u> <u>estimate</u> of $\bar{R}_o$, R_1, the iterative Newton's procedure can be followed until

$$\lim_{n\to\infty} R_n = \bar{R}_o \quad , \qquad (6)$$

where R_n is the estimate of $\bar{R}_o$ after n iterations. The modified R-H model, (4), should be a good procedure to use to obtain R_1. This is because it is a model that has been fit to (3). It has been found for a few sample test cases that if this procedure is followed for obtaining R_1, no more than n=11 iterations are needed to get $\bar{R}_o$ accurate to 7 decimal places. However, to be on the safe side, we have allowed for 25 iterations in subroutine MODRH (described in Section 5) to obtain $\bar{R}_o$.

3.2 Other Rain-Rate Analysis Modifications

Values of the variances about M, S_M^2, about D, S_D^2, and about U, S_U^2, have been obtained zonally. The methodology and rationale for obtaining these zonal constants, and their use in estimating the variance about β, S_β^2, and the variance about $\bar{R}_o$, $S_{R_o}^2$, at a given percentile, $P(\bar{R}_o)$, on the distribu-

Table 1. Zonal means, standard deviations and variances of rain rate prediction input parameters for the U.S.A. Number of data points consists of the number of annual values at a station summed over all stations within a zone.

Zone	M_Z (mm/yr)	S_M (mm/yr)	S_M^2 (mm/yr)^2	U_Z (days/yr)	S_U (days/yr)	S_U^2 (days/yr)^2	D_Z (days/yr)	S_D (days/yr)	S_D^2 (days/yr)^2	Number of stations per zone	Number of data points determining M_Z and S_M	Number of data points determining U_Z and S_U	Number of data points determining D_Z and S_D
1	1326.8	324.45	105267.80	72.635	18.497	342.139	121.01	24.223	586.75	15	369	351	369
2	1261.9	279.85	78316.02	54.619	14.262	203.404	111.29	14.814	219.45	38	880	813	879
3	1080.3	213.06	45394.56	24.041	6.7431	45.469	121.56	12.604	158.86	24	547	489	547
4	1045.6	214.88	46173.41	44.219	9.1807	84.272	129.19	19.085	364.24	13	307	274	307
5	1104.1	314.20	98721.64	37.082	11.812	139.523	145.08	24.454	597.99	18	416	354	416
6	818.60	168.12	28264.33	36.113	8.3339	69.455	137.30	21.733	472.32	35	813	796	813
7	650.15	246.52	60772.11	46.563	10.394	108.035	93.984	16.047	257.51	24	569	524	567
8	921.31	251.85	63428.42	50.797	9.7928	95.902	92.961	18.139	329.02	17	356	355	356
9	334.13	91.904	8445.61	25.156	9.4504	89.302	96.381	19.804	392.20	18	440	392	440
10	456.64	230.19	52987.43	40.303	11.997	143.928	71.077	17.652	311.59	20	504	475	504
11	254.58	118.34	14004.35	29.366	13.177	173.633	68.100	17.026	289.88	10	249	227	249
12	190.50	126.32	15956.74	24.524	13.201	174.266	35.747	15.762	248.44	8	182	166	182
13	611.99	421.50	177662.25	8.6682	5.0650	25.654	88.011	30.600	936.36	11	268	223	268
14	266.87	126.87	16095.99	3.5426	2.3063	5.317	36.508	10.220	104.45	8	179	129	179
15	1137.2	606.42	367745.21	5.4754	3.3126	10.9733	136.95	48.011	2305.06	16	372	305	372
16	1309.9	1016.6	1033475.56	2.3043	1.4893	2.2180	188.45	45.401	2061.25	15	211	92	211
17	283.07	133.40	117795.56	3.9820	2.8821	8.3065	110.10	25.566	653.62	11	197	111	197
18	608.45	228.93	52408.94	7.1282	4.1002	16.8116	115.28	22.916	525.14	2	39	39	39
19	2262.4	1150.1	1322730.01	9.8571	4.9722	24.7227	243.04	41.159	1694.06	2	50	49	50

tion (1) are described in Dutton (1977). Table 1 shows the zonal mean of M, M_z; of D, D_z; and of U, U_z, and the corresponding zonal variances S_M^2, S_D^2, and S_U^2, for the 19 U.S.A. rainfall zones shown in figure 1. The methodology described in Dutton (1977) for rainfall variance analysis uses an approximation that essentially requires that the standard deviation of an input parameter should be small with respect to its mean value. This requirement must also be met if a normal distribution is to be used as the approximate assumed population distribution of any of the parameters M, D, and U, since all three represent means of values that are non-negative.

From a theoretical standpoint, both the Dutton (1977) rain rate variance formulations and the assumed normality of the distribution from which S_M^2, S_D^2, and S_U^2 are chosen, the ratios S_M/M_Z (or S_M/M), S_D/D_Z (or S_D/D), and S_U/U_Z (or S_U/U) should probably be 1/3 or less. It is apparent from table 1 that while 58 percent are indeed $\leq 1/3$, 18 percent lie between 1/3 and 1/2 and 24 percent are $\geq 1/2$. The largest ratio is in zone 16, where $S/M_Z=0.776$. As the ratios become progressively larger than 1/3, the Dutton (1977) rain-rate variance formulations (being derived from the first-order terms of a complicated, multivariable Taylor series) become theoretically progressively larger underestimates of rain-rate variance. The comparisons of data with the Dutton (1977) formulations, which were made in that report, however, indicate, at least for that small data base, that the formulations are realistic.

To avoid concern about the use of a normal distribution in the region where the aforementioned ratios are >1/3, a truncated-normal distribution (truncated below zero) has been used. The assumption was made in Dutton (1977) that a normal distribution of M, D, and U implies a normal distribution of rain rate, $\bar{R}_o$. It has now been further assumed that a truncated (or more properly doubly-truncated at 0 and 365 for D and U) normal distribution of M, D, and U implies a truncated normal distribution of $\overline{R}_o$ (again truncated below $\overline{R}_o=0$). Before proceeding further, however, we must answer the question: why are we using the truncated-normal distribution? It is clear that M, D, U, and $\overline{R}_o$ are all non-negative quantities, so that, in point of fact, it is the normal distribution that should theoretically never be used, since it permits negative values. However, for the ratio of the standard deviation to the mean less than 1/3, more than 99.87 percent of the distribution values are non-negative. This fact, coupled with the widespread usage and tabulation of the normal distribution, make it a convenient distribution to use. Nevertheless, whenever the afore-mentioned ratios are greater than 1/3, the normal distribution begins to allow too much probability of negative values of M, D, U, and R_o. It is therefore necessary to use one of many possible non-negative distribution functions to represent the distribution of these parameters. The choice of the truncated-normal distribution was made because a) it represents a logical extension of the otherwise-used normal distribution for positive values only, and b) it has a non-zero probability of $M=D=U=R_o=0$, a clearly feasible result that some other distributions such as the gamma or Rayleigh distributions do not have. The drawback to the truncated-normal distribution is that it is more difficult to manipulate mathematically than distributions such as the gamma or Rayleigh distributions.

4. INTERPOLATION ERROR PROPAGATION

A large physical segment of the program PRED77, discussed in Section 5, is devoted to an interpolation procedure entitled subroutine "IDBVIP" (Akima, 1975). Some minor modifications of software procedure were necessary in order to use IDBVIP for U.S.A.-data as opposed to European data. Also, the mean-square interpolation error (MSIE) was obtained for the U.S.A. for the input parameters M, D, and U, and are, respectively, denoted as S^2_{Me}, S^2_{De}, and S^2_{Ue}.

In these three cases, as was done for Europe, the total variance can be assumed to be

$$\sigma^2_M = S^2_M + S^2_{Me} , \tag{7}$$

$$\sigma^2_D = S^2_D + S^2_{De} , \tag{8}$$

and

$$\sigma^2_U = S^2_U + S^2_{Ue} , \tag{9}$$

provided the spatial-temporal caused deviations and the interpolation error are uncorrelated.

A specific set of boundaries is needed for optimum use of IDBVIP, which necessitated dividing the U.S.A. into three separate areas*--the conterminous U.S.A., Alaska, and Hawaii--for computer interpolation purposes. Incidentally, it should be recognized that the purpose of the contour maps, figures 4 through 8, is interpolation, and for that matter, could be used to avoid computer interpolation altogether. However, in so doing, the map user sacrifices a quantitative estimate of the error made by such a procedure, and the propagation of that error. If the user retains the computer interpolation, then the only input variables required are estimates of location co-ordinates, station elevation, operating carrier frequency, and path length.

Table 2 shows the estimated values of S_{Me}, S_{De}, and S_{Ue} for the 19 U.S.A. rainfall zones. Also included in table 2 are values for σ_M, σ_D, and σ_U, which result when table 1 is combined with the interpolation errors via (7), (8), and (9). Consequently, if the user wishes to retain the computer interpolation procedure,

---

*Note, not zones as defined earlier.

Table 2
Root-Mean-Square Interpolation Errors and Resultant Variances using data of Table 1.

Zone	S_{Me} (mm/yr)	S_{De} (days/yr)	S_{Ue} (days/yr)	σ_M (mm/yr)	σ_D (days/yr)	σ_U (days/yr)
1	133.8	6.7	11.9	350.9	25.1	21.5
2	164.6	6.5	8.7	324.7	16.2	16.7
3	201.2	14.3	6.8	293.1	19.1	9.6
4	62.9	4.2	4.3	223.9	19.6	10.1
5	285.7	29.9	4.9	424.7	38.6	12.8
6	99.7	9.2	4.6	195.4	23.6	9.6
7	66.1	8.4	5.1	255.2	18.1	11.6
8	152.3	7.3	7.9	294.3	19.6	12.6
9	232.6	39.3	5.9	250.1	44.0	11.1
10	281.0	39.2	17.7	363.3	43.0	21.4
11	340.5	27.5	14.1	360.4	32.4	19.3
12	273.2	15.0	11.3	301.0	21.7	17.4
13	1069.8	55.6	2.7	1149.8	63.4	5.7
14	116.2	13.5	1.3	172.0	16.9	2.7
15	718.5	32.5	1.9	940.2	57.9	3.8
16	599.5	120.8	1.6	1180.2	129.0	2.2
17	354.6	43.3	3.2	378.9	50.3	4.3
18	736.0	54.3	2.4	770.8	59.0	4.8
19	2514.3	199.9	5.9	2764.8	204.1	7.7

he or she finds from tables 1 and 2 that the ratios σ_M/M_Z, σ_D/D_Z, and σ_U/U_Z are considerably larger than the corresponding ratios S_M/M_Z, S_D/D_Z, and S_U/U_Z discussed in the preceding section. It is found that the ratios with interpolation error included are such that now only 35 percent are $\leq 1/3$, 18 percent lie between 1/3 and 1/2, and 47 percent are $\geq 1/2$. Indeed several ratios even exceed unity. At this point, the user is reminded that, if he or she has known data at a site, interpolation error is not to be included on those data. However, when using the IDBVIP interpolation procedure, it is best to be circumspect about its application in those zones where the aforementioned ratios exceed 1/3. In these cases, the user is advised to use the contour maps of figures 4 through 8 instead of computer interpolation.

Two such zones are in Hawaii, where the data base is so small (2 points in each zone) that large interpolation errors are not too surprising. The Hawaiian land mass is so small, yet so mountainous, that orographic effects make the rainfall climate highly variable. Smooth interpolations, such as provided by IDBVIP, cannot be expected to do a very good job as a result. Nor do contour maps do any better! This is why no contouring has been included for Hawaii in figures 4 to 8. Instead, the data base values have been given. Other zones in the U.S.A. that have high ratios are in Alaska and the West. Interpolation errors are probably higher in these zones because the density of data stations is generally lower than in other zones. It is felt (albeit, strictly intuitively) that contour map estimates will provide superior results in these high-error areas. Zones of greatest concern are numbers 11, 12, 13, 16, 17, 18, and 19.

As well as the three variables, M, D, and U, the input variable M_m would also have an interpolation error, but it has been decided not to use the interpolation error for an interpolated M_m because the values are so large as to produce meaningless results in the variance of β. It is not entirely clear why this is so, but a possible reason lies in the inherent difference between M_m and the other input variables. First M_m is a maximum value, whereas M, D, and U, are mean values for a 30-year period. Second, M_m is a monthly value, whereas M, D, and U are annual values. The only need for the interpolation error would be in evaluating the zonal MSIE of β, $S^2_{\beta e}$, which, when added to the zonal variance S^2_β, would produce the resultant zonal variance, σ^2_β, analogous to (7), (8), and (9). Thus, a way has been devised to obtain σ^2_β, without evaluating the interpolation error on M_m.

In Section 2, it was implied that the ratio M/β, was essentially constant (to first order approximation) within a zone--that being the way zones were defined. Hence, we can say, for any particular β and M in a zone,

$$\frac{\beta}{M} = C \quad , \tag{8}$$

where C is a zone-wide constant. Therefore, assuming that this relation will hold for interpolated (estimated) values of M and β as well, it is not difficult to show (Crow et al., 1960) that

$$S^2_{\beta e} = C^2 S^2_{Me} \quad . \tag{9}$$

Thus σ^2_β is obtained in PRED77, and unwarrantedly high values resulting from interpolation error on M_m have been circumvented.

5. PROGRAM PRED77, THE U.S.A. VERSION OF PROGRAM PREDIC

The FORTRAN program package PRED77 consists of basically two parts: an attenuation prediction procedure, and a rain-rate and associated variance prediction procedure. As mentioned in Section 1, the major changes have been made in the rain-rate prediction procedure. It is the purpose of this section to describe the software format of these changes. A listing of PRED77 with these changes incorporated is given in Appendix A, and a basic flow diagram of PRED77 is given in Appendix B.

Some minor changes to the attenuation prediction procedure will be described first. We shall include the input data formatting changes as part of these minor changes, so that computer input requirements for the user are now as follows. The first input data card is an identifier card which uses all 80 columns of the card. The second card contains only site data; i.e., the latitude and longitude of the site of interest, the elevation of the site, and the frequency and distance of the link involving the site. These data are read in each as F10.0 format, starting in column 1, and punched in the order stated above. The third input data card contains only meteorological data for the station, and is inputted as follows. The first piece of data is an integer variable IZONE, the zone in figure 1 that contains the station. At this point, the user should note that this is the last piece of input data which need be specified. The interpolation routine IDBVIP, discussed in Section 4, can now be used to find subsequent unknown input data, if necessary. All data prior to, and including, IZONE, however, must be specified on the input cards, or program execution will fail. IZONE is read in as an I2 format. The remainder of the input data; namely, the pressure, P; the temperature, T; the relative humidity, H; the average annual precipitation, M; the average number of days with precipitation greater than .25 mm, D; the average number of thunderstorm days, U; and, finally, the greatest monthly precipitation recorded in 30 years, M_m, are each read in on an F10.0 format. Data is punched beginning in column 11 of the third card for any of these input data that are known. For those that are not known (unspecified), the appropriate space on the input data card is left blank.

Another change in the attenuation prediction procedure involves the determination of the distribution of attenuation by using a truncated normal distribution, as discussed in section 3.2. This is done physically in subroutine TRUNCN. Subroutine TRUNCN has two satellite subroutines: ERF and ERFCI. ERF contains a numerical analysis procedure (Hastings, 1955) for evaluating the error function and its complement. In ERFCI, a Newton-Raphson iteration is used to find the inverse of the complementary error function. This result is then returned to TRUNCN, where the actual evaluation of the attenuation distribution takes place.

PRED77 interfaces with three main subroutines in the rain rate prediction procedure. These subroutines are TABLUS, VARNCE, and DELTUS. TABLUS, after checking to see if the IDBVIP interpolation procedure is to be used, determines which of the values of the U.S.A. data sample are appropriate for use in that interpolation. TABLUS uses three satellite subroutines: TRIPART, CLSPT and SORT. TABLUS is, of course, also the interface to the interpolation subroutine IDBVIP. TABLUS first checks to see if all of the input data are specified. If all input data are specified, control is passed back to PRED77 with certain flags set so that the rms interpolation error (see section 4.0) is not included in the variance analysis. If some of the optional input is unspecified, interpolation is undertaken by calling TRIPART. The subroutine TRIPART partitions the entire U.S.A. into three areas; a) the conterminous U.S.A., b) the state of Hawaii, and c) the state of Alaska. TRIPART then determines within which of these three areas the location requiring data interpolation is contained. The number of data points used for the interpolation is dependent upon which of the three areas is used. For example, in Hawaii, only four data points exist. Thus only four data points can be used in the interpolation. However, in Alaska and the conterminous U.S.A. there exist 26 and 329 data points, respectively (including AAF's). In these areas only the closest 20 data points are used for the interpolation. The number 20 was obtained from the fact that use of more than 20 data points did not appear to appreciably further minimize the rms interpolation error. Furthermore, fewer than 20 data points should not be used (when possible) to assure a statistically meaningful sample size (Crow et al., 1960). Clearly, in Hawaii more data points are needed for truly meaningful interpolation. A greater density of data points everywhere would also improve interpolation error prediction. The current interpolation, as discussed in Section 4, is often poor, but does provide quantitative interpolation error estimation. The present total U.S.A. data sample is located in an enormous array entitled BLOCK DATA TABLES. It is partitioned into the aforementioned three sets of data where station numbers 1 to 329 are in the conterminous U.S.A., station numbers 330 to 355 are in the state of Alaska, and station numbers 356 to 359 are in the state of Hawaii.

After the area in which the interpolation is to be performed has been found, the geometrically closest 20 data points (except in Hawaii) are found in subroutine SORT. Control is then passed to subroutine CLSPT, where the coordinates of the data points with respect to the desired location are tested to see if they both lie within 0.1 degree of the desired location. If a data point location does satisfy this criterion, the data for that location are substituted in directly as the desired location's values. Thus, no rms interpolation error is included in this special case. Control is now passed back to TRIPART, which passes control immediately back to TABLUS. The user is reminded at this point that schematic sequencing of this procedure and all computer control procedures described herein are shown in the flow diagram of Appendix B. The user is referred there if he or she wishes to know the exact logic followed by the computer.

While still in TABLUS, the optional input data, P, T, H, M, D, U, and M_m, are now tested to see whether they were specified or not. If a value is specified, it is given priority, retained, and used throughout PRED77. If a value is unspecified, the interpolated substitute is to be retained by means of setting an appropriate flag in TABLUS. For P, T, and H, no rms interpolation error is included. Subroutine IDBVIP is now called to obtain those interpolated input data needed at a given desired location.

Control is now passed to the main program PRED77, from whence it is passed to subroutine VARNCE. Subroutine VARNCE determines the zonal variances σ_M^2, σ_D^2, and σ_U^2 for the resultant interpolated or specified input data M, D, and U, respectively, by using a block data statement of the zonal variances entitled BLOCK DATA RMSVAR. The variance is composed of two parts, a spatial-temporal variance and the mean-square interpolation error (see section 4). VARNCE checks the flags set in TABLUS, as discussed above, and adds or omits the mean-square interpolation on error accordingly. Control is then passed back to the main program PRED77, whence control is passed to subroutine DELTUS. Subroutine DELTUS is a major subroutine that incorporates the procedures from the subroutine DELTT of the European prediction program PREDIC plus modifications for the U.S.A., as discussed in detail in Section 3. DELTUS has three satellite subroutines: PARAM, MODRH, and FIT. PARAM gets the needed intermediate parameters used in the R-H and modified R-H models and required for use in DELTUS and MODRH. MODRH determines the rain rate, as discussed in subsection 3.1, by means of Newton's method. DELTUS then determines the variance of the rain rate returned from MODRH. However, in DELTUS, the variance of β, σ_β^2 is determined before the rain-rate variance is determined. This variance σ_β^2 is dependent on whether M_m is specified at the location of interest or not, as discussed in Section 4. If M_m

is specified, only the methodology for obtaining σ_β^2 from σ_M^2 and σ_U^2, as described in Appendix A of Dutton (1977), is used. If M_m is unspecified, (9) is used also. An unsmoothed variance of the rain rate is then determined in DELTUS, whereupon control is passed to subroutine FIT, and the unsmoothed variance is fit with a smooth curve in accordance with techniques described in Appendix A of Dutton (1977). Control is now finally returned to the main program PRED77, where calculations for the mean attenuation and 5 and 95 percent confidence levels of attenuation of the link involving the desired location is undertaken.

6. CONCLUSIONS AND RECOMMENDATIONS

A rain rate prediction procedure has been developed to predict attenuation conditions expected on microwave links in the U.S.A. These results have been incorporated into a computer program PRED77 for making these predictions. The attenuation prediction procedure is, except for some minor changes, exactly the same as it was for Europe, in program PREDIC. It is the *rain-rate* prediction procedure that has been markedly changed, as one might expect, for the U.S.A.

The data base for the U.S.A. model is fairly extensive, yet, because of the somewhat unusual input variables needed for the model, this base is still limited. If, for example, we had chosen to only input total annual precipitation, M, and had determined some of the other variables like D by other means (as was done for Europe), then, depending upon how far we would have carried such a process, we could have had a much larger U.S.A. data base. The data base needs to be much larger in certain highly variable areas, such as mountainous regions and Hawaii.

As a consequence of data base limitations and, possibly to a much smaller degree, the analytic interpolation techniques, the interpolation and its consequent error assessment are at present less than optimum. We have endeavored to provide the user with a quantitative estimate of interpolation error. However, fully meaningful interpolation and interpolation errors remain to be achieved, and it is recommended that such an effort be pursued as soon as possible by both data base enlargement and analytic technique improvement.

It was not the purpose of this report to improve the attenuation prediction procedure for microwave links in the U.S.A., except by improvement of rainfall modeling. Nevertheless, such improvement should remain a priority goal, because, as it stands, there is no attenuation data base from which to make a recommendation as to which of four methods of attenuation prediction to use. These four methods, as designated in Appendix A, are: Methods 1 and 2, corresponding to two extrapolations of the earth-space probability modification factor (Dutton and Dougherty, 1973) to terrestrial link application; Method 3, the method of Barsis et al. (1973), and Method 4, the method of Battesti et al. (1971). In Europe, it was tentatively recommended that consideration be given to the use of the French method--Method 4. So far as this author can tell, however, only Method 3 of Barsis et al. (1973) has received any validation in the U.S.A., and that only by virtue of some limited data taken in Florida (Jones and Sims, 1971) and Mississippi (Skerjanec and Samson, 1971). However, this limited validation motivates the tentative recommendation that Method 3 be used in the U.S.A. Simultaneously, it also motivates the much stronger recommendation that as much U.S.A. attenuation data as possible be checked against the four methods, (or any other methods that may become appropriate) to ascertain which one truly appears to give the best predictions in the U.S.A.

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APPENDIX A. LISTING OF PROGRAM PRED77

```
      PROGRAM PRED77(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C     THIS PROGRAM ESTIMATES ATMOSPHERIC ATTENUATION AND ITS 5 AND 95
C     PERCENT CONFIDENCE LIMITS ON MICROWAVE (8 TO 30 GHZ) TERRESTRIAL
C     LINKS IN THE U.S.A. FOR THE PURPOSES OF THE U.S. ARMY COMMUNICA-
C     TIONS COMMAND BY MEANS OF FOUR DIFFERENT PROCEDURES.  PRIMARY
C     EMPHASIS IS GIVEN TO RAINFALL-CAUSED ATTENUATION.
C
C
C.....INPUT
C
C     THREE CARDS ARE READ IN FOR EACH STATION
C
C      FIRST CARD --
C       STATID - ALPHANUMERIC ARRAY FOR INPUT OF ANY IDENTIFYING HEADER
C                OR COMMENTS,(COLS 1-80,8A10).
C
C      SECOND CARD --
C          XLAT - DEGREES-MINUTES,(DD.MM), LATTITUDE OF DESIRED LOCATION,
C                 (COLS 1-10,F10.0).
C          XLON - DEGREES-MINUTES,(DD.MM), LONGITUDE OF DESIRED LOCATION,
C                 (COLS 11-20,F10.0).
C          ELEV - ELEVATION IN METERS AT DESIRED LOCATION, TO MAP
C                 ACCURACY-ASSUMED TO BE NEAREST 100 FT. OR 35 M,
C                 (COLS 21-30,F10.0).
C             F - CARRIER FREQUENCY IN GHZ. OF TRANSMISSION LINK,
C                 (COLS 31-40,F10.0).
C           DIS - DISTANCE ALONG TRANSMISSION PATH, (COLS 41-50,F10.0).
C
C      THIRD CARD -- METEOROLOGICAL DATA
C
C        IZONE - METEOROLOGICAL ZONE APPLYING TO DESIRED LOCATION,
C                (COLS 1-2,I2).
C
C......NOTE -- IF ANY OR ALL OF THE METEOROLOGICAL DATA LISTED BELOW IS
C              UNKNOWN, LEAVE THE CORRESPONDING FIELD FOR THE UNKNOWN
C              PARAMETER BLANK.
C
C      THIRD CARD -- CONTINUED
C             P - AVERAGE ANNUAL SURFACE PRESSURE IN MILLIBARS,
C                 (COLS 11-20,F10.0).
C            RH - AVERAGE ANNUAL SURFACE RELATIVE HUMIDITY AS A DECIMAL
C                 FRACTION, (COLS 21-30,F10.0).
C             T - AVERAGE ANNUAL TEMPERATURE IN DEGREES CENTIGRADE,
C                 (COLS 31-40,F10.0).
C             M - AVERAGE ANNUAL PRECIPITATION IN MILLIMETERS,
C                 (COLS 41-50,F10.0).
C             D - AVERAGE NUMBER OF DAYS WITH PRECIP. GREATER THAN .25
C                 MM., (COLS 51-60,F10.0).
C             U - NUMBER OF THUNDERSTORM DAYS IN AN AVERAGE YEAR,
C                 (COLS 61-70,F10.0)
C          EMAX - GREATEST MONTHLY PRECIP. RECORDED IN 30 YEARS,
C                 (COLS 71-80,F10.0)
C
C
      COMMON/RRATE/RR(12),VRR(12),PCT(12)
      DIMENSION TMOD(12,4), VTAU(12,4), TAU5(12,4), TAU95(12,4)
      DIMENSION TAUDBT(12), REVTAU(12), RELI(12), HTOP(12), IFLAG(4)
      DIMENSION AT(12), STATID(8)
      REAL M
      DATA RELI(12),HTOP(12)/ 100., 10./
C
C.....READ INPUT DATA.
C
```

```
      READ(5,1000)(STATID(I),I=1,8)
      READ(5,1100)XLAT,XLON,ELEV,F,DIS
      READ(5,1200)IZONE,P,RH,T,M,D,U,EMAX
      WRITE(6,1300)
      WRITE(6,1325)XLAT,XLON,ELEV,F,DIS,IZONE
      WRITE(6,1350)P,T,RH,M,D,U,EMAX
C
C. . .OBTAIN INTERPOLATED METEOROLOGICAL DATA (KNOWN DATA AT DESIRED
C. . .LOCATION IS GIVEN PRIORITY).  USER IS AGAIN CAUTIONED THAT, IF
C. . .DATA IS UNKNOWN, TO LEAVE THE SPACES FOR THE DATA ON THE INPUT
C. . .CARD BLANK.  THIS IS THE INPUT OPTION MENTIONED IN THE MAIN TEXT.
C
      CALL TABLUS(XLAT,XLON,ELEV,P,T,RH,M,D,U,EMAX,IFLAG)
C
C.....TEST TO SEE IF ANY OF THE INTERPOLATED VALUES ARE LESS THAN OR
C        EQUAL TO ZERO.  IF SO, CEASE EXECUTION AND PRINT AN ERROR
C        MESSAGE.  IF NOT, CONTINUE EXECUTION.
C
      TEST= AMIN1(M,D,U,EMAX)
      IF(TEST .GT. 0.0)  GO TO 1
      WRITE(6,1250)
      WRITE(6,1275)
      WRITE(6,1280)M,D,U,EMAX
      STOP
C
C.....CALL VARNCE TO GET VARIANCES OF M, D, AND, U
C
    1 CALL VARNCE(IZONE,IFLAG,VM,VD,VU)
C
C.....CALL DELTUS TO GET THE RAINRATE AND ITS ASSOCIATED VARIANCE
C
      CALL DELTUS(EMAX,M,D,U,VM,VD,VU,BET,IFLAG(4))
      DO 105 I=1,11
  105 RELI(I)=PCT(I)
       GAM= 1. + 0.085*(F - 3.5)*EXP(-0.006 * F * F)
      GAM= (1.14 - 0.07*((F - 2.)**(1./3.))) * GAM
      IF(GAM .LT. 1.0)  GAM=1.0
      CAY= GAMMA(F)
      WAV= 29.9793/F
C
C.....IF METHOD = 1, THE PROBABILITY MODIFICATION FACTOR, PT1, IS USED.
C.....IF METHOD = 2, THE PROBABILITY MODIFICATION FACTOR, PT2, IS USED.
C.....IF METHOD = 3, THE METHOD OF BARSIS ET AL. (1973) IS USED.
C.....IF METHOD = 4, THE METHOD OF BATTESTI ET AL. (1971) IS USED.
C
C.....CALCULATIONS OF ATTENUATION FOR METHODS 3 AND 4.
C
      DO 100 I=1,11
      IF(RR(I) .LT. 1.0)  GO TO 220
      GOTO(195,205,180,205,205,180,180,185,190,185,200,200,190,200,170,
     1 170,165,195,195)IZONE
C
C.....DETERMINE STORM TOP HEIGHTS
C
  165 HTOP(I)= 0.344144*RR(I) + 11.4796
      GOTO 215
  170 HTOP(I)=9.46601759*(RR(I)**.182178)
      GOTO 215
  180 HTOP(I)=10.444337860*(RR(I)**.1419197)
      GOTO 215
  185 HTOP(I)=14.910713780*(RR(I)**.0765891)
      GOTO 215
  190 HTOP(I)=10.63765431*(RR(I)**.100104)
      GOTO 215
```

```
  195 HTOP(I)=14.03483057*(RR(I)**0.0690994)
      GOTO 215
  200 HTOP(I)=5.686528747*(RR(I)**.213556)
      GOTO 215
  205 HTOP(I)=11.68119168*(RR(I)**.109989)
      GOTO 215
  220 HTOP(I)= 9.0
      TMOD(I,3)= 0.0
      TMOD(I,4)= 0.0
      VTAU(I,3)= 0.0
      VTAU(I,4)= 0.0
      GO TO 99
  215 HTOP(I)= AMAX1(HTOP(I),9.0)
C
C.....CALCULATE METHOD 3.
C
      METHOD=3
      CALL RAINRT(RR(I),DIS,RM)
      DM= DIS
      IF(DM.GT.22.0) DM=22.0
      TMOD(I,METHOD)=CAY*(RM**GAM)*DM
      VTAU(I,METHOD)= VRR(I) * (TMOD(I,METHOD)*GAM/RR(I))**2.
C
C.....CALCULATE METHOD 4.
C
      METHOD=4
      RF= REDCO(DIS,PCT(I))
      TMOD(I,METHOD)= CAY * ((RF * RR(I))**GAM) * DIS
      VTAU(I,METHOD)= VRR(I) * (TMOD(I,METHOD)*GAM/RR(I))**2.
   99 CALL ATCOS(F,T,P,RH,HTOP(I),RELI(I),BET,RR(I),AT(I),WAV)
      TAUDBT(I)= AT(I) * DIS
  100 CONTINUE
C
C.....CALCULATIONS OF ATTENUATION FOR METHODS 1 AND 2.
C
      CALL ATCOS(F,T,P,RH,HTOP(12),RELI(12),BET,1.E-06,AT(12),WAV)
      TAUDBT(12)= AT(12) * DIS
      DO 160 METHOD=1,2
      CALL PROMO(WAV,DIS,METHOD,TAUDBT,REVTAU,RELI,HTOP)
      DO 160 I=1,11
      IF(RR(I) .GT. 1.0)  GO TO 106
       TMOD(I,METHOD)= 0.0
       VTAU(I,METHOD)= 0.0
       GO TO 160
  106  TMOD(I,METHOD)= REVTAU(I) + TAUDBT(12)
      VTAU(I,METHOD)= VRR(I) * (TMOD(I,METHOD)*GAM/RR(I))**2.
  160 CONTINUE
C
C.....CALCULATE 5 AND 95 PERCENT CONFIDENCE LIMITS OF ATTENUATION
C.....DISTRIBUTION FOR ALL METHODS (1-4).
C
      CALL TRUNCN(TMOD,VTAU,TAU5,TAU95)
C
C. . .OUTPUT HEADERS AND RESULTS.
C
  153 WRITE(6,1400)(STATID(I),I=1,8)
      DO 300 J=1,4
      IF(J.EQ.1) WRITE(6,1450)
      IF(J.EQ.2) WRITE(6,1451)
      IF(J.EQ.3) WRITE(6,1452)
      IF(J.EQ.4) WRITE(6,1453)
      WRITE(6,1500)(PCT(I),I=1,11)
      WRITE(6,2000)(RR(I),I=1,11)
      WRITE(6,2500)(VRR(I),I=1,11)
```

```
      WRITE(6,3000)(TMOD(I,J),I=1,11)
      WRITE(6,3500)(VTAU(I,J),I=1,11)
      WRITE(6,4000)(TAU95(I,J),I=1,11)
  300 WRITE(6,4500)(TAU5(I,J),I=1,11)
      STOP
 1000 FORMAT(8A10)
 1100 FORMAT(5F10.0)
 1200 FORMAT(I2,8X,7F10.0)
 1250 FORMAT(///1X,20H********************,5X,10HERROR EXIT,5X,20H******
     1**************,//)
 1275 FORMAT(1X,71HM, D, U, OR EMAX, INTERPOLATED VALUE(S) ARE LESS THAN
     1 OR EQUAL TO ZERO./)
 1280 FORMAT(1X,3HM =,E15.7,5X,3HD =,E15.7,5X,3HU =,E15.7,5X,6HEMAX =,E1
     15.7)
 1300 FORMAT(1H1,28HRESULTS FROM PROGRAM PRED77./)
 1325 FORMAT(1X,41HINPUT DATA FOR MICROWAVE LINK AS FOLLOWS./1X,6HXLAT =
     1,F7.3,5X,6HXLON =,F7.3,5X,6HELEV =,F7.3,5X,7HFREQ. =,F7.3,5X,5HDIS
     2 =,F7.3,5X,7HIZONE =,I3)
 1350 FORMAT(1X,37HINPUT METEOROLOGICAL DATA AS FOLLOWS./1X,8HPRESS. =,F
     17.3,5X,7HTEMP. =F8.4,5X,11HREL. HUM. =,F6.4,5X,3HM =,F9.4,5X,3HD =
     2,F7.3,5X,3HU =,F7.3,5X,6HEMAX =,F7.3)
 1400 FORMAT(///1X,20H********************,5X,8A10,5X,20H***************
     1*****,///)
 1450 FORMAT(51H THE PROBABILITY MODIFICATION FACTOR, PT1, IS USED.,//)
 1451 FORMAT(51H THE PROBABILITY MODIFICATION FACTOR, PT2, IS USED.,//)
 1452 FORMAT(44H THE METHOD OF BARSIS ET AL. (1973) IS USED.,//)
 1453 FORMAT(46H THE METHOD OF BATTESTI ET AL. (1971) IS USED.,//)
 1500 FORMAT(1X,12HPCT         = ,11(F9.3,1X)/)
 2000 FORMAT(1X,12HR(MM/HR)    = ,11(F9.3,1X)/)
 2500 FORMAT(1X,12HVAR(R)      = ,11(F9.3,1X)/)
 3000 FORMAT(1X,12HATTEN(DB)   = ,11(F9.3,1X)/)
 3500 FORMAT(1X,12HVAR(ATT)    = ,11(F9.3,1X)/)
 4000 FORMAT(1X,12HATT.(95)    = ,11(F9.3,1X)/)
 4500 FORMAT(1X,12HATT.(5)     = ,11(F9.3,1X)///)
      END
```

```
      SUBROUTINE DELTUS(EMAX,EM,D,U,VM,VDE,VU,BETA,IFLAG4)
C
C     THIS SUBROUTINE USES THE METHOD OF DUTTON(1977) , AND, SOME NEW
C        VARIANCE PREDICTION PROCEDURES TO OBTAIN VARIATIONS OF T=1 MIN.
C        RAINRATES IN TERMS OF ESTIMATED STANDARD DEVIATIONS, BASED ON
C        CURRENTLY AVAILIABLE YEAR TO YEAR PRECIPITATION DATA.
C
C.....INPUT
C        EM,VM- ANNUAL AND ASSOCIATED VARIANCE OF PRECIP. AT EACH
C           STATION (MM)
C        D,VD- NUMBER AND ASSOCIATED VARIANCE OF DAYS WITH PRECIP.
C           GREATER THAN .25 MM
C        U,VU- NUMBER AND ASSOC. VARIANCE OF THUNDERSTORM DAYS IN AN
C           AVERAGE YEAR
C        EMAX= GREATEST MONTHLY PRECIP. RECORDED IN 30 YEARS
C        IFLAG4- THIS DETERMINES THE VARIANCE FORMULATION FOR BETA.  IF
C           IT IS ZERO, THE FIRST METHOD OF DUTTON (1977) IS USED.  IF IT
C           IS NOT ZERO, THE ZONAL CRITERION IS USED.
C
C.....OUTPUT
C        BETA- RATIO OF THUNDERSTORM PRECIP. TO TOTAL ANNUAL PRECIP.
C
C       OUTPUT FOUND IN /RRATE/
C        RR- ESTIMATED 1-MIN. RAINRATE DETERMINED IN MODRH
C        VRR- ESTIMATED VARIANCE OF RAINRATE
C
      COMMON/RRATE/RR(12),VRR(12),PCT(12)
      DIMENSION VRO(12), XX(12), IWICH(12)
C
C.....DATA STATEMENT CONTAINING COEFFICIENTS FOR MODIFIED RICE-
C       HOLMBERG (RH) MODEL PARAMETERS.  IT ALSO CONTAINS THE MEAN VALUE
C       AND VARIANCE OF THE MODIFIED R-H PARAMETER RBAR1T FOR T=1 MIN.
C
      DATA B1,B3,B4,B5,S3/3.96,1.223E-03,-0.645,-7.921E-03,0.1916/
      DATA RBAR11,S1/33.6642,0.8017/
C
C.....FIND THE VARIANCES FOR THE RAINRATES BY USING
C        1) PARAM-TO GET NEEDED PARAMETERS USED BY THE OTHER ROUTINES
C        2) MODRH- TO FIND THE ACTUAL RAINRATE.
C        3) DELTUS- TO GET THE VARIANCE OF THE RAINRATE
C
      CALL PARAM(EMAX,EM,D,U,BETA,BETA0,RP1,RBAR1T,RBAR2T,T1T,T2T,TST,RS
     1           T,RBAR11,Q)
C
C.....OBTAIN RAIN RATES AND THEIR VARIANCES FOR 12 SELECTED PERCENTAGES
C       OF AN AVERAGE YEAR.
C
      CALL MODRH(RP1,RBAR1T,RBAR2T,T1T,T2T,RST,TST)
C
C.....DETERMINE THE VARIANCE OF BETA.
C
      IF(IFLAG4 .NE. 0.0)  GO TO 2
         ARG= -0.35 * (1. + 0.125*EM)/U
       EXPON= EXP(ARG)
       PARTM= -BETA0 * 0.0875 * EXPON/U
       PARTU= 0.7 * BETA0 * (1. + 0.125*EM) * EXPON/(U**2.)
      VBET= VM*(PARTM**2.) + VU*(PARTU**2.)
         GO TO 3
    2 VBET= VM * (BETA/EM)**2.
    3  BMR= BETA * EM/(RBAR11**2.)
C
C.....DETERMINE VARIANCES OF THE PARAMETERS IN THE MODIFIED R-H MODEL
C        AND COMBINE WITH CERTAIN PARTIAL DERIVATIVES (APP.D  DUTTON ET
C        AL. 1974)
```

```
C
      DO 1000 K=1,12
C
C.....DETERMINE IN WHAT RANGE THE RAINRATE LIES IN
C
        T= 87.66 * PCT(K)
        IF(RR(K) .GE. 5.0)  GO TO 100
          GO TO 101
 100    IF(RR(K) .GT. 30.0)  GO TO 102
          GO TO 103
C
C.....RAINRATE LIES IN THE LOW RANGE.
C
  101   ARG= (T1T + T2T)/T
       PRRPT= ALOG(ARG)
       PRT2T= RP1/(T1T + T2T)
        TLOW1= PRRPT * B3
        TLOW2= PRT2T * BETA/RBAR11
        TLOW3= PRRPT * B4
        TLOW4= PRT2T * EM/RBAR11
        VR1= ((TLOW1 + TLOW2)**2.)*VM + ((TLOW3 + TLOW4)**2.)*VBET
        VR2= ((PRRPT*B5 + PRT2T*B1)**2.)*VOE + ((PRT2T * BMR * S1)**2.)
        VR3= ((PRRPT * S3)**2.)
      VRO(K)= VR1 + VR2 + VR3
          GO TO 1000
C
C.....RAINRATE LIES IN HIGH RANGE
C
  102  PRR11= ALOG(T1T/T) - 1.
       PRT1T= RBAR11 * (1. + ALOG(T/T1T))/T1T
        THIGH1= PRT1T * BETA/RBAR11
        THIGH2= PRT1T * EM/RBAR11
        THIGH3= PRR11 - (PRT1T*BMR)
         VR1=  THIGH1 * THIGH1 * VM
         VR2= THIGH2 * THIGH2 * VBET
         VR3= THIGH3 * THIGH3 * S1 * S1
      VRO(K)= VR1 + VR2 + VR3
          GO TO 1000
C
C.....RAINRATE LIES IN THE MIDDLE RANGE.  DETERMINE PARTIALS FIRST
C
  103  PRTST= 4. * (RST**4) * (ALOG(TST/T)**3)/TST
       PTSTRS= -2.340347319 * T1T * Q/(RST*RST)
         ARG= (T1T + T2T)/T1T
         BOT= ((30./RBAR11) - (5./RP1) + ALOG(ARG))**2
       PRSTRP= -4.225/(BOT * RP1 * RP1)
       PRSTT2= -0.845/((T1T + T2T) * BOT)
         ARG= (30./RBAR11) - (T2T/(T1T + T2T))
       PRSTR1= 0.845 * ARG/(BOT * RBAR11)
       PRSTT1= -0.845 * ARG/(BOT * T1T)
       PRRST= PRTST * TST * (ALOG(TST/T) + (RST*PTSTRS/TST))/RST
         ARG= (30./RBAR11) + (T1T * 2.340347319 * PRSTT1/(RST * RST))
       PTSTT1= Q * (1. - ARG)
         ARG= (1./RBAR11) + (2.340347319 * PRSTR1/(RST * RST))
       PTSTR1= Q * T1T * ((30./(RBAR11*RBAR11)) - ARG)
C
C.....DETERMINE CERTAIN CONSTANTS USED IN FINDING THE MID-RANGE RAINRATE
C         VARIANCE
C
        TMID1= PRSTRP * B3
        TMID2= PRSTT1 * BETA/RBAR11
        TMID3= PTSTT1 * BETA/RBAR11
        TMID4= PRSTRP * B4
        TMID5= PRSTT1 * EM/RBAR11
```

```
       TMID6= PTSTT1 * EM/RBAR11
       TMID7= PRSTRP * B5
       TMID8= PRSTT1 * BMR
       TMID9= PTSTT1 * BMR
         VTEMP= (PTSTRS * (TMID1 + TMID2) + TMID3) * PRTST
      VR1= (((TMID1 + TMID2)*PRRST + VTEMP)**2.)* VM
         VTEMP= (PTSTRS * (TMID4 + TMID5) + TMID6)* PRTST
      VR2= (((TMID4 + TMID5)*PRRST + VTEMP)**2.)* VBET
         VTEMP= (PRRST * PRSTT2) + (PRTST * PTSTRS * PRSTT2)
      VR3= (((PRRST*TMID7 + PRTST*PTSTRS*TMID7) + VTEMP*B1)**2.)* VDE
         VTEMP= ((PRSTR1 - TMID8)*PTSTRS + PTSTR1 - TMID9) * PRTST
      VR4= (((PRSTR1 - TMID8)*PRRST + VTEMP)**2.)*S1 * S1
         VTEMP= PRRST*PRSTRP + PRTST*PTSTRS*PRSTRP
      VR5= (VTEMP * S3)**2.
      VRO(K)= VR1 + VR2 + VR3 + VR4 + VR5

 1000       CONTINUE
C
C.....FIT THE RAIN RATE VARIANCE RESULTS WITH A SMOOTH CURVE FOR PREDIC-
C       TION PURPOSES, AND PERFORM THE PREDICTION FOR THE 12 PERCENTS OF
C       AN AVERAGE YEAR.
C
       NARG= 0
       WT= 0.0
      DO 2000 I=1,12
       ARG= (T1T + 0.5*T2T)/(87.66 * PCT(I))
       IF(ARG .LE. 1.)  GO TO 2000
       ARG= ALOG(ARG)
       NARG= NARG + 1
       XX(NARG)= ALOG(ARG)
       IWICH(NARG)= I
       IF(RR(I) .GT. 30.)  WT= WT + 1.
 2000 CONTINUE
      DO 2500 I=1,NARG
       VRR(I)= VRO(IWICH(I))
       IF(RR(I).GT.30. .AND. WT.NE.0.0)  VRR(I)= VRR(I)*FLOAT(NARG)/WT
       VRR(I)= ALOG(VRR(I))
 2500 CONTINUE
      CALL FIT(XX,VRR,A,B,NARG)
       AE= EXP(A)
      DO 2750 I=1,12
       IF(RR(I) .GT. 1.0)  GO TO 1
         VRR(I)= PCT(I-1) * VRR(I-1)/PCT(I)
         IF(RR(I) .NE. 0.0)  GO TO 2750
          VRR(I)= 0.0
          GO TO 2750
   1   ARG= (T1T + 0.5*T2T)/(87.66 * PCT(I))
       IF(ARG .GT. 1.)  GO TO 2749
       VRR(I)= VRO(I)
       GO TO 2750
 2749  XX(I)= ALOG(ARG)
       VRR(I)= AE * XX(I)**B
 2750 CONTINUE
                     RETURN
                     END
```

```
      SUBROUTINE PARAM(EMAX,EM,D,U,BETA,BETA0,RP1,RBAR1T,RBAR2T,T1T,T2T,
     1                   TST,RST,RBAR11,Q)
C     THIS SUBROUTINE DETERMINES VARIOUS PARAMETERS USED IN FINDING THE
C        1-MIN RAINRATE AND ITS ASSOCIATED VARIANCES.
C
C.....INPUT- 30 YEAR STATION MEANS
C        EM= ANNUAL PRECIP. AT EACH STATION (MM)
C        D= NUMBER OF DAYS IN AN AVERAGE YEAR WITH PRECIP. GREATER THAN
C          .25 MM
C        U= NUMBER OF THUNDERSTORM DAYS IN AN AVERAGE YEAR
C        EMAX= GREATEST MONTHLY PRECIP. RECORDED IN 30 YEARS
C        RBAR11= MEAN RBAR1T FOR T= 1 MIN.
C
C
C.....OUTPUT
C
C        BETA= RATIO OF THUNDERSTORM PRECIP. TO TOTAL ANNUAL PRECIP.
C        RP1,T1T,T2T,RBAR1T,RBAR2T,TST,RST,Q- PARAMETERS IN R-H MODEL
C          CORRESPONDING TO A 1-MIN. RAINRATE
      COMMON/RRATE/RR(12),VRR(12),PCT(12)
       DATA B3,B4,B5,B6/1.223E-03,-0.645,-7.921E-03,1.92/
C
C.....DETERMINE BETA- THE THUNDERSTORM RATIO - FIRST
C
         EXPON= -5.*EXP(-.004*EMAX)
     BETA0= 0.03 + .97*EXP(EXPON)
         EXPON= -.35*(1. + (.125*EM))/U
      BETA= BETA0*(.25 + 2.*EXP(EXPON))
C
C.....DETERMINE RBAR1T
C
         C1= 7.04709132E-03
         EXPON= -BETA*EM/8766.
         B1= 13.457*EXP(EXPON)
         A1= 1. + (65.67864*EXP(EXPON))
         ARG= (1./11.) + C1*0.065397403
      RBAR1T= A1 + B1*ALOG(ARG)
      IF(ABS(RBAR11 - RBAR1T) .GT. 5.0)  RBAR1T= RBAR11
C
C.....DETERMINE T1T
C
    1       T1T= BETA*EM/RBAR1T
C
C.....DETERMINE T2T
C
    2 T2T= 3.96 * D
C
C.....DETERMINE RBAR2T
C
      RBAR2T= (1. -  BETA)*EM/T2T
C
C.....DETERMINE RPRIME
C
      RP1= B3*EM + B4*BETA + B5*D + B6
C
C.....DETERMINE RST
C
         ARG= (T1T + T2T)/T1T
         ARG= ALOG(ARG) + (30./RBAR1T) - (5./RP1)
      RST= 0.844998/ARG
C
C.....DETERMINE Q
C
```

```
      ARG= ((30.**.25)/RST) - (30./RBAR1T)
      Q= EXP(ARG)
C
C.....DETERMINE TST
C
      TST=T1T * Q
C

                        RETURN
                        END
```

```
      SUBROUTINE MODRH(RP1,RBAR1T,RBAR2T,T1T,T2T,RST,TST)
C     THIS SUBROUTINE FINDS THE RAINRATE USING THE MODIFIED R-H
C        MODEL TO GIVE AN INITIAL ESTIMATE AND THEN USES THE NEWTON-
C        RAPHSONS METHOD OF FINDING ZEROE*S FOR AN ITERATIVE REFINEMENT.
C
C.....INPUT
C        RP1,RBAR1T,RBAR2T,T1T,T2T,RST,TST- PARAMETERS USED IN THE
C          MODIFIED R-H MODEL.
C        PCT- PERCENT EXPECTANCY IN HOURS PER YEAR OF RAINRATE
C
C.....OUTPUT (/RRATE/)
C        RR- 1 MIN. RAINRATE LOCATED IN /RRATE/
C
      COMMON/RRATE/RR(12),VRR(12),PCT(12)
C
C.....INITIALIZE SOME CONSTANTS AND DETERMINE THE 5 AND 30 MM. RAIN-
C        RATE ACCORDING TO THE MODIFIED R-H MODEL.
C
        B= -1./RBAR1T
        B1= -0.453074/RBAR2T
        B2= -2.857143/RBAR2T
       T5= (T1T + T2T) * EXP(-5./RP1)
       T30= T1T * EXP(-30./RBAR1T)

      DO 1000 KK=1,12
       T= 87.66 * PCT(KK)
C
C.....TEST TO PREVENT NEGATIVE RAIN RATES, SINCE THE MODEL ALLOWS THOSE
C        RAIN RATES TO OCCUR.
C
       TOF0= T1T + T2T
        IF(T .LT. TOF0)  GO TO 4
          RAPROX= 0.0
          GO TO 1000
C
C......DETERMINE IN WHAT INTERVAL THE RAINRATE LIES IN AND FIND AN
C        INITIAL ESTIMATE FO  THE ITERATIVE REFINEMENT.
C
  4    IF(T .LT. T5)  GO TO 1
C
C......LOW R INITIAL ESTIMATE
C
        ARG= (T1T + T2T)/T
      RAPROX= RP1 * ALOG(ARG)
        GO TO 3
  1     IF(T .LE. T30)  GO TO 2
C
C......MID R INITIAL ESTIMATE
C
      RAPROX= (RST * ALOG(TST/T))**4.
        GO TO 3
C
C......HIGH R INITIAL ESTIMATE
C
  2   RAPROX= RBAR1T * ALOG(T1T/T)
C
C.....THE ITERATIVE REFINEMENT IS DONE HERE.  THE NEWTON-RAPHSON*S
C        METHOD IS USED ON THE MODIFIED R-H MODEL WITH THE INITIAL
C        ESTIMATE AS THE FIRST APPROXIMATION.  AN ARBITRARY ERROR
C        CRITERION OF 4.E-08 IS DEMANDED FOR CONVERGENCE.
C
C.....IF THE ITERATIVE TECHNIQUE FAILS THE LAST VALUE OF RAPPROX IS
C        SUBSTITUTED IN AND AN ERROR MESSAGE IS PRINTED OUT.  PROCESSING
C        THEN CONTINUES WITH THE NEXT VALUE OF PCT.
```

```
C
   3   DO 500 I=1,25
         FOFR1= T1T * EXP(B*RAPROX)
          ARG= B1 * RAPROX
          IF(ARG .GT. -65.)  GO TO 6
          FOFR2= 0.0
           FOFR3= 0.0
           GO TO 8
   6     FOFR2= 0.35 * T2T * EXP(ARG)
          ARG= B2 * RAPROX
          IF(ARG .GT. -65.)  GO TO 7
          FOFR3= 0.0
           GO TO 8
   7      FOFR3= 0.65 * T2T * EXP(ARG)
   8     FOFR= T - (FOFR1 + FOFR2 + FOFR3)

         FOFRP1= B * FOFR1
         FOFRP2= B1 * FOFR2
         FOFRP3= B2 * FOFR3
        FOFRP= -(FOFRP1 + FOFRP2 + FOFRP3)

        RAPROX= RAPROX - (FOFR/FOFRP)
C
C......PROVIDED THE ABOVE CONDITION ON THE RAIN RATE IS MET, RAPPROX
C         HAS TO BE GREATER THAN ZERO.  THUS IF RAPPROX IS LESS THAN
C         ZERO, SUBSTITUTE RAPPROX EQUALS ZERO.
C
          IF(RAPROX .LT. 0.0)  RAPROX= 0.0

  500     IF(ABS(FOFR) .LT. 4.E-08)  GO TO 1000
C
C.....IF THE ITERATIVE SOLUTION FAILS THE ERROR MESSAGE IS PRINTED HERE
C
       WRITE(6,9)T,RAPROX
       WRITE(6,5)FOFR, FOFR1, FOFR2, FOFR3, FOFRP
 1000 RR(KK)= RAPROX

          RETURN
   5  FORMAT(1X,6HFOFR =,E15.7,5X,7HFOFR1 =,E15.7,5X,7HFOFR2 =,E15.7,5X,
     17HFOFR3 =,E15.7/1X,7HFOFRP =,E15.7///)
   9  FORMAT(///1X,39HITERATIVE METHOD IN MODRH FAILS FOR T =,F7.4,5X,13
     1HLAST RAPROX =,E15.7//)
          END
```

```
      SUBROUTINE FIT(X,Y,A,B,N)
C
C     THIS SUBROUTINE PERFORMS A LINEAR REGRESSION ON THE INPUT DATA
C         X AND Y FIT THROUGH THE MEAN SUCH THAT
C                Y= BX + A
C
C.....INPUT
C        X - THE INDEPENDENT VARIABLES OF THE REGRESSION.
C        Y - THE DEPENDENT VARIABLES OF THE REGRESSION.
C        N - THE NUMBER OF INDEPENDENT OR DEPENDENT VARIABLES.
C
C.....OUTPUT
C         B - SLOPE OF THE REGRESSION LINE
C         A - INTERCEPT OF THE REGRESSION LINE
C
C..........NOTE - ALSO DETERMINED ARE THE MEAN VALUES OF X AND Y - XBAR
C                 AND YBAR, THE VARIANCE OF X - VARX, AND, THE COVARIANCE
C                 OF X AND Y - COV
C
      DIMENSION X(N), Y(N)
C
C.....INITIALIZATION
C
       SUMX= 0.0
       SUMY= 0.0
       SUMXY= 0.0
       SUMXX= 0.0
C
C.....DETERMINE THE SUMS OF X, Y, X*Y, AND, X SQUARED
C
      DO 1000 I=1,N
       SUMX= SUMX + X(I)
       SUMY= SUMY + Y(I)
       SUMXY= SUMXY + X(I)*Y(I)
 1000  SUMXX= SUMXX + X(I)**2.
C
C.....DETERMINE THE OUTPUT - SEE NOTE ABOVE
C
      XBAR= SUMX/FLOAT(N)
      YBAR= SUMY/FLOAT(N)
      VARX= (SUMXX - XBAR*SUMX)/FLOAT(N - 1)
      COV= (SUMXY - XBAR*SUMY)/FLOAT(N - 1)
      B= COV/VARX
      A= YBAR - B*XBAR
      RETURN
      END
```

```
      SUBROUTINE VARNCE(IZONE,IFLAG,VM,VD,VU)
C
C     THIS SUBROUTINE FINDS THE ZONAL VARIANCES OF METEOROLOGICAL DATA
C        USED IN FINDING THE VARIANCE OF THE RAINRATE.  THESE ZONAL
C        VARIANCES ARE COMPOSED OF THE SPATIAL TEMPORAL VARIANCE, AND
C        IF THIS DATA IS UNKNOWN, THE MEAN SQUARE ERROR DUE TO THE
C        APPROXIMATION METHODS USED TO FIND THIS METEOROLOGICAL DATA.
C        IF ANY, OR ALL, OF THIS METEOROLOGICAL INPUT DATA IS KNOWN, THE
C        MEAN SQUARE ERROR FOR THE KNOWN DATA IS NOT INCLUDED.
C
C.....INPUT
C
C       IZONE- ZONE NUMBER OF THE ZONE CONTAINING THE INTERPOLATED
C              STATION
C       IFLAG- A SINGLY DIMENSIONED INTEGER ARRAY THAT DETERMINES WHICH
C              VARIANCE FORMULATION IS USED.  THE ARRAY IS SET UP AS
C           FOLLOWS
C                    IFLAG(1)- SPECIFIES THE EM VARIANCE FORMULATION
C                    IFLAG(2)- SPECIFIES THE D VARIANCE FORMULATION
C                    IFLAG(3)- SPECIFIES THE U VARIANCE FORMULATION
C                    IFLAG(4) - DETERMINES WHETHER EMAX WAS SPECIFIED OR
C                               NOT.  THIS ULTIMATELY DETERMINES THE
C                               FORMULATION USED FOR THE VARIANCE OF BETA.
C                               IT IS NOT USED IN THIS SUBROUTINE.
C
C.....OUTPUT
C
C       VM- VARIANCE OF EM(M),THE AVERAGE ANNUAL PRECIPTATION
C       VD- VARIANCE OF D, THE AVERAGE NUMBER OF DAYS WITH PRECIP.
C       VU- VARIANCE OF U, THE AVERAGE NUMBER OF THUNDERSTORM DAYS
C
      COMMON/STATS/ VAREM(19),VARD(19),VARU(19)
      COMMON/RMSERR/ RMSM(19), RMSD(19), RMSU(19)
      DIMENSION IFLAG(4)
C
C.....FIND VARIANCE FOR EACH PIECE OF INPUT DATA
C        IF STATEMENT LABEL IS LESS THAN 500, THIS DATA WAS UNKNOWN AND
C        HAD TO BE APPROXIMATED.  IF THE STATEMENT LABEL IS GREATER
C        THAN 400, THE INPUT DATA WAS SPECIFIED AND ONLY THE SPATIAL,
C        TEMPORAL VARIANCE IS USED.
C
      DO 1000 I=1,3
       IF(IFLAG(I) .NE. 0)  GO TO (100,200,300)I
       GO TO (500,600,700)I
  100 VM= VAREM(IZONE) + RMSM(IZONE)*RMSM(IZONE)
       GO TO 1000
  200 VD= VARD(IZONE) + RMSD(IZONE)*RMSD(IZONE)
       GO TO 1000
  300 VU= VARU(IZONE) + RMSU(IZONE)*RMSU(IZONE)
       GO TO 1000
  500 VM= VAREM(IZONE)
       GO TO 1000
  600 VD= VARD(IZONE)
       GO TO 1000
  700 VU= VARU(IZONE)
 1000 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CMPLXN (WAVE, T, CSQ, HIMMK, CFPT, CTPT, C, D)
C
C     THIS ROUTINE USES THE DEBYE FORMULATION FOR THE DIELECTRIC CONSTAN
C     OF WATER.  SEE KERR,D.E. (1951), PROPOGATION OF SHORT RADIO WAVES.
C     (MCGRAW-HILL BOOK CO. INC., NEW YORK, N.Y.) PG. 675
C
C
C.....INPUT
C
C     WAVE = FREE-SPACE WAVELENGTH IN CM.
C
C     T = TEMPERATURE IN DEGREES CENTIGRADE.
C
C.....OUTPUT
C
C     CSQ=DIELECTRIC INFLUENCE OF WATER ON SCAT IN ATTCOE.
C
C     HIMMK=DIELECTRIC INFLUENCE OF WATER ON ABS IN ATTCOE.
C     CFPT NOT USED IN TEST70.
C
C     C=REAL PART OF THE DIELECTRIC COEFFICIENT OF WATER.
C
C     D=IMAGINARY PART OF THE DIELECTRIC COEFFICIENT OF WATER.
C
      DIMENSION E00 (6), DDLAM (6), TTAB (6)
      DATA(TTAB(I),I=1,6)/0.0E0,1.0E1,1.8E1,2.0E1,3.0E1,4.0E1/
      DATA(E00(I),I=1,6)/8.8E1,8.4E1,8.1E1,8.0E1,7.54E1,7.3E1/
      DATA(DDLAM(I),I=1,6)/3.59E0,2.24E0,1.66E0,1.53E0,1.12E0,8.59E-1/
C
C     ESTABLISH CONSTANTS FOR USE IN THE DEBYE FORMULA.
C
      EIN = 5.5
      E0 = TERP (6, T, TTAB, E00)
      DLAM = TERP (6, T, TTAB, DDLAM)
      B = DLAM / WAVE
      A = (E0 - EIN) / (1.0 + (B * * 2))
      C = EIN - 1.0
      D = EIN + 2.0
      E = A + C
      H = A + D
      G = A * B
      HIMMK = (G * (H - E)) / ((H * * 2) + (G * * 2))
      CSQ = (((E * H + (G ** 2)) / ((H ** 2) + (G ** 2))) ** 2) + HIMMK
C    1 ** 2
      C = A + EIN
      D = - A * B
      U = D / 45.
      V = ((20. * C * D + 10. * D) * (15. * (C * * 2) - 15. * (D * * 2)
     1+ 60. * C + 60.) + (30. * C * D + 60. * D) * ( - 10. * (C * * 2) +
     2 10. * (D * * 2) - 10. * C + 20.)) / ((15. * (C * * 2) - 15. * (D
     3* * 2) + 60. * C + 60.) * * 2 + (30. * C * D + 60. * D) * * 2)
      W = ((12. * C * D - 18. * D) * (15. * (C * * 2) - 15. * (D * * 2)
     1+ 60. * C + 60.) + (30. * C * D + 60. * D) * ( - 6. * (C * * 2) +
     26. * (D * * 2) + 18. * C - 12.)) / ((15. * (C * * 2) - 15. * (D *
     3* 2) + 60. * C + 60.) * * 2 + (30. * C * D + 60. * D) * * 2)
      Y = (D * (30. * C + 45.) - 30. * D * (C - 1.)) / ((30. * C + 45.)
     1* * 2 + (30. * D) * * 2)
      CFPT = 3. * U + 3. * W + 5. * Y
      CTPT = 3. * V
      RETURN
      END
```

```
      SUBROUTINE CRANE (F, A, B, C, D)
C
C     THIS SUBROUTINE GETS THE COEFFICIENTS A AND B IN A*(M**B) AND
C     C AND D IN C*(M**D) FOR FREQUENCY, F, BELOW 94 GHZ, FOLLOWING
C     CRANE, R.K., MICROWAVE SCATTERING PARAMETERS FOR NEW ENGLAND RAIN,
C     MIT LINCOLN LABORATORIES REPORT R TR 426, AD 647798, OCT. 1966.
C     A AND B ARE COEFFICIENTS USED IN COMPUTING THE RAIN ATTENUATION
C     COEFICIENT, C AND D ARE COEFFICIENTS USED IN COMPUTING THE RAIN
C     REFLECTIVITY PER UNIT VOLUME.  M IS THE LIQUID WATER CONTENT IN
C     G/M**3.  THE SUBROUTINE USES THE APPROXIMATE F SQUARED ABSORPTION
C     DEPENDENCY.
C
      X1 = X3 = 0.1
      X2 = X4 = 1.0
C
C     OBTAIN COEFFICIENTS FOR CALCULATION OF RAIN ATTENUATION PER UNIT
C     LENGTH.
C
      IF (F .LT. 1.29) GO TO 160
      IF (F .LT. 2.8) GO TO 100
      IF (F .LT. 8.0) GO TO 125
      IF (F .LT. 9.35) GO TO 130
      IF (F .LT. 15.5) GO TO 135
      IF (F .LT. 35.0) GO TO 140
      IF (F .LT. 70.0) GO TO 145
      IF (F .LT. 94.0) GO TO 150
      PRINT 1502
100   Y1 = 1.8E-4
      Y2 = 1.8E-3
      Y3 = 9.1E-4
      Y4 = 1.05E-2
      F1 = 1.29
      F2 = 2.8
      GO TO 155
125   Y1 = 9.1E-4
      Y2 = 1.05E-2
      Y3 = 1.3E-2
      Y4 = 0.18
      F1 = 2.8
      F2 = 8.0
      GO TO 155
130   Y1 = 1.3E-2
      Y2 = 0.18
      Y3 = 2.0E-2
      Y4 = 0.32
      F1 = 8.0
      F2 = 9.35
      GO TO 155
135   Y1 = 2.0E-2
      Y2 = 0.32
      Y3 = 6.1E-2
      Y4 = 1.3
      F1 = 9.35
      F2 = 15.5
      GO TO 155
140   Y1 = 6.1E-2
      Y2 = 1.3
      Y3 = 0.41
      Y4 = 5.8
      F1 = 15.5
      F2 = 35.0
      GO TO 155
145   Y1 = 0.41
      Y2 = 5.8
```

```
      Y3 = 1.5
      Y4 = 10.1
      F1 = 35.0
      F2 = 70.0
      GO TO 155
 150  Y1 = 1.50
      Y2 = 10.1
      Y3 = 1.40
      Y4 = 12.0
      F1 = 70.0
      F2 = 94.0
 155  B1 = ALOG (Y2 / Y1) / ALOG (X2 / X1)
      A1 = Y1 / (X1 * * B1)
      B2 = ALOG (Y4 / Y3) / ALOG (X4 / X3)
      A2 = Y3 / (X3 * * B2)
      A = (((F * F - F1 * F1) * (A2 - A1)) / (F2 * F2 - F1 * F1)) + A1
      B = ((F2 - F) / (F2 - F1)) * B1 + ((F - F1) / (F2 - F1)) * B2
      GO TO 165
 160  A = 0.000973 * F * F
      B = 1.0
C
C     OBTAIN COEFFICIENTS FOR COMPUTING RAIN REFLECTIVITY PER UNIT
C     VOLUME.
C
 165  IF (F .LT. 1.29) GO TO 210
      IF (F .LT. 2.8) GO TO 170
      IF (F .LT. 8.0) GO TO 175
      IF (F .LT. 9.35) GO TO 180
      IF (F .LT. 15.5) GO TO 185
      IF (F .LT. 35.0) GO TO 190
      IF (F .LT. 70.0) GO TO 195
      IF (F .LT. 94.0) GO TO 200
 170  Y1 = 530.0
      Y2 = 2.1E+4
      Y3 = 600.0
      Y4 = 2.3E+4
      F1 = 1.29
      F2 = 2.80
      GO TO 205
 175  Y1 = 600.0
      Y2 = 2.3E+4
      Y3 = 690.0
      Y4 = 2.5E+4
      F1 = 2.8
      F2 = 8.0
      GO TO 205
 180  Y1 = 690.0
      Y2 = 2.5E+4
      Y3 = 610.0
      Y4 = 2.1E+4
      F1 = 8.0
      F2 = 9.35
      GO TO 205
 185  Y1 = 610.0
      Y2 = 2.1E+4
      Y3 = 1000.0
      Y4 = 3.3E+4
      F1 = 9.35
      F2 = 15.5
      GO TO 205
 190  Y1 = 1000.0
      Y2 = 3.3E+4
      Y3 = 890.0
      Y4 = 1.2E+4
```

```
      F1 = 15.5
      F2 = 35.0
      GO TO 205
195   Y1 = 690.0
      Y2 = 1.2E+4
      Y3 = 170.0
      Y4 = 910.0
      F1 = 35.0
      F2 = 70.0
      GO TO 205
200   Y1 = 170.0
      Y2 = 910.0
      Y3 = 51.0
      Y4 = 260.0
      F1 = 70.0
      F2 = 94.0
205   D1 = ALOG (Y2 / Y1) / ALOG (X2 / X1)
      C1 = Y1 / (X1 * * D1)
      D2 = ALOG (Y4 / Y3) / ALOG (X4 / X3)
      C2 = Y3 / (X3 * * D2)
      C = (((F * F - F1 * F1) * (C2 - C1)) / (F2 * F2 - F1 * F1)) + C1
      D = ((F2 - F) / (F2 - F1)) * D1 + ((F - F1) / (F2 - F1)) * D2
      GO TO 220
210   PRINT 1500
1500  FORMAT (1X,*FREQUENCY TOO LOW FOR REFLECTIVITY*)
1502  FORMAT (1X,*FREQUENCY TOO HIGH*)
220   RETURN
      END
```

```
      SUBROUTINE SFCG(TA, REH, PR, HGT, ZH, RO, EMZ1, EMZ2, T)
C
C     THIS SUBROUTINE CALCULATES THE LIQUID WATER CONTENT IN A RAIN-
C     STORM. DETAILS ARE IN A METEOROLOGICAL MODEL FOR USE IN THE STUDY
C     OF RAINFALL EFFECTS ON ATMOSPHERIC RADIO TELECOMMUNICATIONS, BY
C     E.J. DUTTON, OFFICE OF TELECOMMUNICATIONS REPORT OT/TRER 24,
C     DECEMBER, 1971.
C
C.....INPUT
C
C     HGT=STORM TOP HEIGHT IN KILOMETERS.
C
C     PR=SURFACE PRESSURE IN MILLIBARS.
C
C     REH=SURFACE RELATIVE HUMIDITY AS A DECIMAL FRACTION.
C
C     RO=SURFACE RAINFALL RATE IN MM/HR.
C
C     TA=SURFACE TEMPERATURE IN DEGREES KELVIN.
C
C     ZH=HEIGHT ABOVE EARTHS SURFACE IN KILOMETERS.
C
C.....OUTPUT
C
C     EMZ1=CONTRIBUTION IN G/M(3) OF CONVECTIVE RAINSTORMS TO LIQUID
C     WATER CONTENT.
C
C     EMZ2=CONTRIBUTION IN G/M(3) OF STRATIFORM RAINSTORMS TO LIQUID
C     WATER CONTENT.
C
C
C     NOTE - SUBROUTINE SFCG USES FUNCTION ESUBS.
C
      REAL L
C
C     EVALUATE THE LIQUID WATER CONTENTS, EMZ1, OF A CONVECTIVE STORM.
C     SEE, ESTIMATION OF RADIO RAY ATTENUATION IN CONVECTIVE RAINFALLS,
C     BY E.J. DUTTON, JOURNAL OF APPLIED METEOROLOGY, VOL. 6, AUG. 1967,
C     PP. 662-668.
C
      Z = 1000. * ZH
      HIT = 1000. * HGT
      C1 = 1.9031
      C2 = 1.5625
      TD = TA / (1. - 1.8594E-4 * TA * ALOG (REH))
      L = (123. + .227 * (TD - 273.16)) * (TA - TD)
      HTE = ((RO / C1) * * (1. / C2)) + (2. * L / 1852.0)
      IF ((Z / 1852.0) .LT. HTE)  GO TO 105
      EMZ1 = 0.0
      GO TO 115
  105 RR = C1 * (((HTE - (L / 1852.0)) - ABS ((Z - L) / 1852.0)) * * C2)
      BZ = 8.2 * (RR * * ( - .21))
      EMZ1 = 64. * 3.1415927 * (BZ * * ( - 4))
C
C     COMPUTE STRATIFORM RAIN LIQUID CONTENTS,EMZ2, BELOW THE STORM
C     CLOUD BASE.
C
  115 B = 8.2 * (RO * * ( - .21))
      EML = 64. * 3.1415927 * (B * * ( - 4))
      IF(Z.GT.L) GO TO 125
      EMZ2 = EML
      T = TA - Z * 9.8E-3
      GO TO 135
C
```

```
C     COMPUTE EMZ2 WITHIN THE STORM CLOUD.
C
 125  TL = TA - L * 9.8E-3
      E = ESUBS (TL)
      P = PR * EXP ((980.62 / 28704.) * ( - L) * (2. / (TA + TL)))
      W = (E * .622) / P
      TS = 9.8E-3 * ((1. + (W * 597.3 / (TL * 6.8557E-2))) / (1. + ((W *
     1 22.191E4) / (TL * TL * 1.64537E-2))))
      T = TA - L * 9.8E-3 - (Z - L) * TS
      EXZ = EXP ( - .064 * TS * (Z - L))
      EXH = EXP ( - .064 * TS * (HIT - L))
      TBZ = TL - .5 * TS * (Z - L)
      TBH = TL - .5 * TS * (HIT - L)
      R = 2.8704E-3
      R1 = 2.8704E4
      GAMZ = ((.622 * E / (R * TBZ)) * (EXZ - 1.) - (.622 * 980.62 * E /
     1 (.064 * TS * R * R1 * TBZ * TBZ)) * (EXZ - 1.))
      GAMH = ((.622 * E / (R * TBH)) * (EXH - 1.) - (.622 * 980.62 * E /
     1 (.064 * TS * R * R1 * TBH * TBH)) * (EXH - 1.))
      EMZ2 = EML * (1.0 - (GAMZ / GAMH))
      IF(EMZ2.LT.0.0) EMZ2 = 0.0
 135  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PROMO(WAVE,D,N,TAUDBT,REVTAU,RELI,HTOP)
C
C. . .THIS SUBROUTINE PERFORMS THE MODIFICATION OF ATTENUATION OF MICRO-
C     WAVE TERRESTRIAL LINKS FOR METHODS 1 AND 2, DESCRIBED IN THE MAIN
C     PROGRAM.
C
C.....INPUT
C          WAVE - CARRIER WAVELENGTH IN CM.
C          D - PATH LENGTH IN KM.
C          N - INTEGER CORRESPONDING TO METHOD 1 OR 2.
C          HTOP - STORM TOP HEIGTH.
C          RELI - PER CENT OF TIME GIVEN ATTENUATION IS EXPECTED TO BE
C                 EXCEEDED
C          TAUDBT - ATTENUATION ALONG A LINK EXPERIENCING HOMOGENOUS
C                   RAINFALL.
C
C.....OUTPUT
C          REVTAU - ACTUAL PREDICTED PATH ATTENUATION DUE TO RAIN.
C
      DIMENSION RELIT(12), EMTAU(12), TAUDBT(12), REVTAU(12), RELI(12)
      DIMENSION HTOP(12)
      F=29.9793/WAVE
      RFSQ=F*F/225.0
      DO 10 I=1,12
      IF(TAUDBT(I) .NE. 0.0)  GO TO 1
      EMTAU(I)= 1.
      GO TO 2
  1    ARG= 16994.70663 * HTOP(I)
       ARG= SQRT(ARG)/D
      EMTAU(I)= RFSQ * ARG * 0.987/TAUDBT(I)
      IF(N .EQ. 2)  EMTAU(I)= 2. * EMTAU(I)
  2   RELIT(I)= RELI(I) * EMTAU(I)
 10   CONTINUE
      DO 20 I=1,12
      IF(RELIT(I) .LT. RELI(I))  GO TO 8
      EMTAU(I)= 1.0
      REVTAU(I)=TAUDBT(I)
      GO TO 20
  8   REVTAU(I)= EXTERP(12,RELI(I),RELIT,TAUDBT)
 20   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WATER(T, P, RHO, WAVE, WN, GAMAR, GAMANR, PHW)
C
C     THIS SUBROUTINE CALCULATES ATMOSPHERIC ABSORPTION PER UNIT LENGTH
C     DUE TO ATMOSPHERIC WATER VAPOR FOR FREQUENCIES ROUGHLYIN THE RANGE
C     5-70 GHZ. USES VAN VLECK FORMULATION (SEE RADIO METEOROLOGY, PG.
C     272).
C
C.....INPUT
C
C     T=TEMPERATURE IN DEGREES KELVIN, AT LOCATION ON TRANSMISSION
C     PATH OF INTEREST.
C
C     P=PRESSURE IN MILLIBARS, AT LOCATION ON TRANSMISSION PATH OF
C     INTEREST.
C
C     RHO=ATMOSPHERIC WATER VAPOR DENSITY IN G/M(3), AT LOCATION ON
C     TRANSMISSION PATH OF INTEREST.
C
C     WAVE=WAVELENGTH IN CENTIMETERS.
C
C.....OUTPUT
C
C     WN=RECIPROCAL OF WAVELENGTH.
C
C     GAMAR=CONTRIBUTION OF WATER RESONANCE LINE.
C
C     GAMANR=NON-RESONANT CONTRIBUTION TO WATER VAPOR ABSORPTION IN
C     DB/KM.
C
C     PHW=PHASE DISPERSION IN RADIANS/KM.  SEE, CALCULATED TROPOSPHERIC
C     DISPERSION AND ABSORPTION DUE TO THE 22 GHZ. WATER VAPOR LINE,
C     BY H. J. LIEBE, IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION,
C     VOL. AP-17, NO. 5, SEPT. 1969.
C
      C1 = 0.00361
      C2 = 0.06089
      B = 0.00708
      WNR = 0.7417
      WN = 1.0 / WAVE
      F = 29.9793 / WAVE
      F0 = 22.23515
      DF = F0 - F
      A = 0.08478 * (P / 1013.25)
      X = 318.0 / T
      D = A * (1.0 + B * RHO) * (X * * 0.625)
      FORMM = (WN - WNR) * * 2 + D * * 2
      FORMM = 1.0 / FORMM
      FORMP = (WN + WNR) * * 2 + D * * 2
      FORMP = 1.0 / FORMP
      FORM = D * (FORMM + FORMP)
      TT = (X * * 2.5) * EXP(-644.0 * (1.0 / T - 1.0 / 318.0))
      YR = C1 * TT * FORM * (WN * *2)
      YNR = C2 * D * X * (WN * * 2)
      GAMAR = YR * RHO
      GAMANR = YNR * RHO
      GG=0.0186823*RHO+0.0028129*(P-RHO*T/216.68)*((300.0/T)**0.63)
      PHW=(4.19163E-2)*F*0.110132*DF/(DF*DF+GG*GG)
      RETURN
      END
```

```
      SUBROUTINE OXYGEN(T,R,RHO,PLAMDA,RWAV,GAMAU)
C
C     THIS SUBROUTINE CALCULATES ATMOSPHERIC ABSORPTION PER UNIT LENGTH
C     DUE TO ATMOSPHERIC OXYGEN FOR FREQUENCIES ROUGHLY IN THE RANGE
C     5-45 GHZ. USES VAN VLECK FORMULATION (SEE RADIO METEOROLOGY, PAGE
C     272).
C
C.....INPUT
C
C     PLAMDA=WAVELENGTH IN CENTIMETERS.
C
C     R=PRESSURE IN MILLIBARS AT LOCATION ON TRANSMISSION PATH OF
C     INTEREST.
C
C     RHO=ATMOSPHERIC WATER VAPOR DENSITY IN G/M(3), AT LOCATION ON
C     TRANSMISSION PATH OF INTEREST.
C
C     T=TEMPERATURE IN DEGREES KELVIN, AT LOCATION ON TRANSMISSION PATH
C     OF INTEREST.
C
C.....OUTPUT
C
C     GAMAU=OXYGEN ABSORPTION IN DB/KM.
C
C     RWAV=RECIPROCAL OF WAVELENGTH.
C
      PW=(4.615E-3)*RHO*T
      P=R-PW
      D=0.049*(P/1013.25)*((300./T)**.75)
      RWAV=1./PLAMDA
      RWAV2=RWAV*RWAV
      D2=D*D
      F1=D/(RWAV2+D2)
      F2=D/((RWAV-2.)**2+D2)
      F3=D/((RWAV+2.)**2+D2)
      GAMAU=.34*RWAV2*((293./T)**2)*(F1+F2+F3)*(P/1013.25)
      RETURN
      END
```

```
      SUBROUTINE ATCOS(FR,T,P,RH,HTOP,PROB,BETA,R,ATE,WAV)
C
C
C     THIS SUBROUTINE DETERMINES THE TOTAL ATMOSPHERIC ATTENUATION PER
C        UNIT LENGTH
C
C.....INPUT
C        FR - FREQUENCY IN GHZ.
C        T - AVERAGE TEMPERATURE IN DEGREES CENTIGRADE
C        P - AVERAGE PRESSURE
C        RH - AVERAGE RELATIVE HUMIDITY
C        HTOP - STORM TOP HEIGHT
C        BETA - RATIO OF THUNDERSTORM RAIN TO NON-THUNDERSTORM RAIN
C        WAV - CARRIER WAVELENGTH IN CM.
C        PROB - PERCENT OF TIME FOR WHICH RESULTS ARE DESIRED
C        R - RAINRATE CORRESPONDING TO PROB
C
C.....OUTPUT
C
C        ATE - TOTAL ATMOSPHERIC ATTENUATION PER UNIT LENGTH IN DB/KM
C
      PI= 4. * ATAN(1.0)
      TK=T+273.16
      CALL RATTCO(WAV,TK,P,RH,HTOP,0.2,R,AT,PROB,BETA,SCAT,PHIRR)
      SRHO=216.68*ESUBS(TK)*RH/TK
      IF(FR .LE. 45.0)  CALL OXYGEN(TK,P,SRHO,WAV,RWAV,OXAT)
      IF(FR .GT. 45.0)  CALL TOPOXY(TK,P,WAV,1,OXAT,SRHO,GAMAUP)
      CALL WATER(TK,P,SRHO,WAV,WN,WAT1,WAT2,PHW)
C
C.....DETERMINE ATE
C
  200 ATE=2.0*AT+OXAT+WAT1+WAT2
      CALL REFRAC(4,3,6,T-P,RH,ENS,D0,W0)
      PHIRD=PHIRR+PHW
      PHIT=(2.0E+5*PI/WAV)*(1.0+1.0E-6*ENS)+PHIRD
      RETURN
      END
```

```
      SUBROUTINE RAINRT(R0,RSS,RB)
C
C     THIS SUBROUTINE MODIFIES THE RAIN RATE IN ACCORDANCE WITH THE
C     PROCEDURE OF BARSIS ET AL. (1973).
C
C     INPUT
C
C      R0 - UNMODIFIED (POINT) RAIN RATE IN MM/HR.
C     RSS - PATH LENGTH IN KM.
C
C     OUTPUT
C
C     RB - MODIFIED (PATH) RAIN RATE IN MM/HR.
C
      DIMENSION RAT(3),PL(3)
      DATA PL(1),PL(2),PL(3)/ 5., 10., 22./
      IF(R0.LE.10.0)225,230
  225 RTB=1.0
      GO TO 250
  230 RAT(1)=-.09076754672*ALOG(R0)+1.209
      RAT(2)=-.1889180996*ALOG(R0)+1.435
      IF(R0.GT.28.0)235,240
  235 RAT(3)=-.1387074521*ALOG(R0)+1.036771423
      GO TO 245
  240 RAT(3)=-.3959540635*ALOG(R0)+1.911717924
  245 RSSS= RSS
      IF(RSSS.GT.22.0) RSSS=22.0
      RTB=TERP(3,RSSS,PL,RAT)
  250 RB=RTB*R0
      RETURN
      END
```

```
      SUBROUTINE TOFOXY(T,P,PLAMDA,L,GAMAU,ARROW,GAMAUP)
C
C     THIS SUBROUTINE CALCULATES ATMOSPHERIC ABSORPTION PER UNIT LENGTH
C     DUE TO ATMOSPHERIC OXYGEN FOR FREQUENCIES ROUGHLY IN THE RANGE
C     45-70 GHZ. SEE, AS AN  XAMPLE, FALCONE, V.J., ATMOSPHERIC
C     ATTENUATION OF MICROWAVE POWER, J. MICROWAVE POWER (CANADA), VOL.5
C     NO.4, DEC) 1970, PP.269-278.
C
C.....INPUT
C
C     T=TEMPERATURE IN DEGREES KELVIN.
C
C     P=PRESSURE IN MILLIBARS.
C
C     PLAMDA=WAVELENGTH IN CENTIMETERS.
C
C     L=ACCOUNTED FOR IN DEGP77.
C
C     ARROW=ATMOSPHERIC WATER VAPOR DENSITY ON TRANSMISSION PATH OF
C     INTEREST.
C
C.....OUTPUT
C
C     GAMAU=OXYGEN ABSORPTION COEFFICIENT IN DB/KM.
C
C     GAMAUP=PHASE DISPERSION DUE TO OXYGEN IN RADIANS/KM.
C
C
      COMMON /BLOCK2 /PMUPL (49), PMUM (49), PMUNOT (49), RSRLN1 (49), R
     1SRLN2 (49)
      REAL L3
C
      VP = T * ARROW / 216.68
      IF(L.EQ.2) GO TO 105
      X1 = .021333
      X2 = .04523
      X3 = .36748
      X4 = .027351
      L3 = ALOG (X3)
      DXDLOG = (X2 - X1) / (ALOG (X4) - L3)
  105 RLMDA = 1.0 / PLAMDA
      BB = 2.068666098 / T
      SUM = 0.0
      SUMP = 0.0
      FEE = 0.0
      NN = 49
      X = (P + VP) / 1013.25
      IF (X .GT. X3) GO TO 110
      IF (X .LT. X4) GO TO 115
      DLT1 = DLT2 = X1 + DXDLOG * (ALOG (X) - L3)
      GO TO 120
  110 DLT1 = DLT2 = X1
      GO TO 120
  115 DLT1 = DLT2 = X2
      GO TO 120
  120 DLT1 = DLT1 * (300. / T) * X
      DLT2 = DLT2 * (300. / T) * X
      DLTNUA = 0.5 * (DLT1 + DLT2)
      IF(L.EQ.2) GO TO 135
      DO 130 K = 1, NN, 2
      PK = K
C
C     CALCULATION OF PMUPL, AND PMUM, THE SQUARES OF THE MAGNETIC DIPOLE
C     MOMENTS OF THE OXYGEN MOLECULE FOR CERTIAN PERMISSIBLE QUANTUM
```

```
C       MECHANICAL TRANSITIONS. ( SEE FALCONE, 1970)
C
        PMUPL (K) = PK * (2. * PK + 3.) / (PK + 1.)
        PMUM (K) = (PK + 1.) * (2. * PK - 1.) / PK
C
C       CALCULATION OF PMUNOT, THE SQUARE OF THE MAGNETIC DIPOLE MOMENT OF
C       THE OXYGEN MOLECULE WHOSE RESONANCE FREQUENCY IS ZERO (DIAGONAL
C       ELEMENTS OF THE MAGNETIC MOMENT OF THE OXYGEN MOLECULE). (SEE
C       FALCONE (1970))
        PMUNOT (K) = (PK * PK + PK + 1.0) / (PK * (PK + 1.0))
  130   PMUNOT (K) = PMUNOT (K) * (2. * PK + 1.) * 2.
        CALL FREQ
  135   DO 140 K = 1, NN, 2
        PK = K
        FAC = EXP ( - BB * PK * (PK + 1.))
        CALL FARM (DLT1, RSRLN1 (K), RLMDA, AA, AAP)
        CALL FARM (DLT2, RSRLN2 (K), RLMDA, AB, ABP)
        CALL FARM (DLTNUA, FEE, RLMDA, AC, ACP)
        AC = AC * 0.5
        TERM = (AA * PMUPL (K) + AB * PMUM (K) + AC * PMUNOT (K)) * FAC
        TERMP = (AAP * PMUPL (K) + ABP * PMUM (K) + ACP * PMUNOT (K)) * FA
       1C
        SUM = SUM + TERM
        SUMP = SUMP + TERMP
  140   CONTINUE
C
C       DETERMINATION OF THE OXYGEN ABSORPTION COEFFIENT, GAMAU AND
C       GAMAUP, THE PHASE DISPERSION DUE TO OXYGEN.
C
        GAMAU = SUM * 59.4681828 * P / (T * T * T)
        GAMAU = GAMAU / (PLAMDA * PLAMDA)
        GAMAUP = SUMP * 6.846527564 * P / (T * T * T)
        GAMAUP = GAMAUP / (PLAMDA * PLAMDA)
        RETURN
        END
```

```
      SUBROUTINE RATTCO(WAVE,TA,PRE,REL,HITE,ZHH,RO,AT,RELY,BETA,SCATR,
     1                  PHIR)
C
C     THIS SUBROUTINE CALCULATES RAIN ATTENUATION, PROVIDED AN
C     AIR/GROUND PATH IS USED FROM SURFACE METEOROLOGICAL DATA AND
C     RELIABILITY REQUIREMENTS.
C
C.....INPUT
C
C     WAVE=WAVELENGTH IN CENTIMETERS.
C
C     TA=SURFACE TEMPERATURE IN DEGREES KELVIN.
C
C     PRE=SURFACE PRESSURE IN MILLIBARS.
C
C     REL=SURFACE RELATIVE HUMIDITY AS A DECIMAL FRACTION.
C
C     HITE=STORM TOP HEIGHT IN KILOMETERS.
C
C     ZHH=HEIGHT ABOVE EARTHS SURFACE IN KILOMETERS.
C
C     RO=SURFACE RAINFALL RATE IN MILLIMETERS PER HOUR.
C
C     RELY=PERCENT OF AN AVERAGE YEAR.
C
C     BETA=RATIO OF THUNDERSTORM RAIN TO NON-THUNDERSTORM RAIN (SEE
C     EARLIER REFERENCE IN TEST30).
C
C.....OUTPUT
C
C     SCATR=RAINFALL REFLECTIVITY IN KM(-1).
C
C     PHIR=PHASE DELAY PER UNIT LENGTH DUE TO RAIN, IN RADIANS/KM.
C
C     AT=ATTENUATION COEFFICIENT DUE TO RAIN IN DB/KM.
C
      DIMENSION PF (3), FACT (3)
      DATA (PF = 0.01, 0.1, 1.0)
      IF(RO .NE. 0.0)  GO TO 1
         SCATR= 0.0
         PHIR= 0.0
         AT= 0.0
         RETURN
C
C
C     OBTAIN APPROPRIATE LIQUID WATER CONTENTS, EMZ1 AND EMZ2, COEF-
C     FICIENTS A, B, A1, B1 FOR THEIR CONVERSION TO REFLECTIVITY, AND
C     WATER DIELECTRIC COEFFICIENTS, CC AND DD.
C
    1 FR= 29.9793/WAVE
      CALL SFCG(TA, REL, PRE, HITE, ZHH, RO, EMZ1, EMZ2, UNW)
      CALL CRANE (FR, A, B, A1, B1)
      TAC = TA - 273.16
      CALL CMPLXN (WAVE, TAC, CSQ, HIMMK, CFPT, CTPT, CC, DD)
C
C     OBTAIN AN EMPERICAL FACTOR, FAC, FOR CONVERSION OF RAYLEIGH
C     PREDICTED PHASE DELAY IN THE MIE REGION.
C
      FP = 0.025970 * FR - 0.50135
      IF (FR .LE. 19.31) FP = 0.0
      FQ = 0.0148888889 * FR - 0.402
      IF (FR .LE. 27.0) FP = 0.0
      FACT (1) = 1.0 + FP
      FACT (2) = 1.0 + FQ
```

```
      FACT (3) = 1.0
      FAC = TERP (3, RELY, FF, FACT)
      IF (RELY .GT. 1.0) FAC = 1.0
C
C     CALCULATE PHASE DELAYS AND ATTENUATION REFLECTIVITY BY USING
C     APPROPRIATE COMBINATIONS OF STRATIFORM RAIN, EMZ1, AND CONVECTIVE
C     RAIN,EMZ2.
C
      U = (0.3 * 3.1415927 / WAVE) * (FAC * ((CC - 1.) * (CC + 2.) + DD
     1* DD)) / ((CC + 2.) * (CC + 2.) + DD * DD)
      PHIR = U * EMZ1
      AT = A * (EMZ1 * * B)
      IF ((ABS (RELY - 0.1)) .LT. 0.01) AT = BETA * A * (EMZ1 * * B)  +
     1(1. - BETA)   * A * (EMZ2 * * B)
      IF ((ABS (RELY - 0.1)) .LT. 0.01) PHIR = BETA * U * EMZ1 + (1. - B
     1ETA)   * U * EMZ2
      IF ((RELY - 0.1) .GE. 0.01) AT = A * (EMZ2 * * B)
      IF ((RELY - 0.1) .GE. 0.01) PHIR = U * EMZ2
      C = (2.E-7 / 3.) * (316.01812) * CSQ / (WAVE * * 4)
      X = C * A1 * (EMZ1 * * B1)
      Y = C * A1 * (EMZ2 * * B1)
      E = 0.84 * B1
      SCATR = Y
  100 RETURN
      END
```

```
      SUBROUTINE REFRAC (KT, KP, KH, TM, PR, HU, EN, D, W)
C
C     THIS SUBROUTINE CALCULATES THE REFRACTIVITY (REFRACTIVE INDEX) AT
C     SPECIFIC LOCATIONS (HEIGHTS) IN THE ATMOSPHERE FOR VARIOUS KINDS
C     OF METEOROLOGICAL INPUT PARAMETERS.
C
C.....INPUT
C
C     THE TEMPERATURE, PRESSURE, AND HUMIDITY DATA CAN BE INPUT INTO
C     SUBROUTINE REFRAC IN A VARIETY OF UNITS.  THE VALUES OF KT, KP,
C     AND KH DETERMINE WHICH SET OF UNITS THE SUBROUTINE WILL USE.  THE
C     FOLLOWING IS A LEGEND OF VALUES FOR KT, KP, AND KH.
C
C     KT = 1  TEMPERATURE TO BE SPECIFIED IN RANKINE.
C     KT = 2  TEMPERATURE TO BE SPECIFIED IN FAHRENHEIT.
C     KT = 3  TEMPERATURE TO BE SPECIFIED IN REAUMUR.
C     KT = 4  TEMPERATURE TO BE SPECIFIED IN CENTIGRADE.
C     KT = 5  TEMPERATURE TO BE SPECIFIED IN KELVIN.
C
C     KP = 1  PRESSURE TO BE SPECIFIED IN MILLIMETERS OF MERCURY.
C     KP = 2  PRESSURE TO BE SPECIFIED IN INCHES OF MERCURY.
C     KP = 3  PRESSURE TO BE SPECIFIED IN MILLIBARS.
C
C     KH = 1  DEW POINT TEMPERATURE TO BE SPECIFIED IN THE SAME UNITS AS
C             USED WITH THE TEMPERATURE, ACCORDING TO THE VALUE OF KT
C             ABOVE.
C     KH = 2  WET BULB TEMPERATURE TO BE SPECIFIED IN THE SAME UNITS AS
C             USED WITH THE TEMPERATURE, ACCORDING TO THE VALUE OF KT
C             ABOVE.
C     KH = 3  SPECIFIC HUMIDITY TO BE SPECIFIED IN GRAMS PER KILOGRAM.
C     KH = 4  MIXING RATIO TO BE SPECIFIED IN GRAMS PER KILOGRAM.
C     KH = 5  WATER VAPOR DENSITY TO BE SPECIFIED IN GRAMS PER METER
C             CUBED.
C     KH = 6  RELATIVE HUMIDITY TO BE SPECIFIED AS A DECIMAL FRACTION.
C     KH = 7  VAPOR PRESSURE TO BE SPECIFIED IN UNITS AS DETERMINED BY
C             THE VALUE OF KP ABOVE.
C
C     HU = HUMIDITY IN UNITS AS DETERMINED BY KH ABOVE.
C     PR = PRESSURE IN UNITS AS DETERMINED BY KP ABOVE.
C     TM = TEMPERATURE IN UNITS AS DETERMINED BY KT ABOVE.
C
C.....OUTPUT
C
C     EN=REFRACTIVITY IN N-UNITS (PARTS PER MILLION OF REFRACTIVE INDEX)
C     D=DRY TERM OF REFRACTIVITY IN N-UNITS.
C     W=WET TERM OF REFRACTIVITY IN N-UNITS.
C
C     NOTE - SUBROUTINE REFRAC MUST BE USED WITH FUNCTION ESUBS(T).
C
      T = TM
      P = PR
      H = HU
      GO TO (100, 105, 110, 115, 120), KT
  100 T = T - 459.69
  105 T = .555555555 * T - 17.7777777
      GO TO 115
  110 T = 1.25 * T
  115 T = T + 273.
  120 GO TO (125, 130, 135), KP
  125 P = 25.4 * P
  130 P = 1.333224 * P
  135 GO TO (140, 140, 175, 180, 185, 190, 195), KH
  140 GO TO (145, 150, 155, 160, 165), KT
  145 H = H - 459.69
```

```
 150  H = .555555555 * H - 17.7777777
      GO TO 160
 155  H = 1.25 * H
 160  H = H + 273.
 165  E = ESUBS (H)
      IF(KH.EQ.1)  GO TO 215
C
C     PSYCHROMETRIC FORMULA , PG. 366  LIST,R.J. (1958) SMITHSONIAN
C     METEOROLOGICAL TABLES. (SMITHSONIAN INSTITUTION , WASHINGTON D.C.)
C
      E = E - (.66E-3 * (1. + .115E-2 * (H - 273.))) * (T - H) * P
      GO TO 215
 175  H = H / (1. - H * 1.E-3)
 180  H = H * 1.E-3
      X = T - 273.
C
C     GOFF-GRATCH FORMULATION FOR CORRECTION FACTOR FW.
C     SEE PG. 340  SMITHSONIAN METEOROLOGICAL TABLES (1958)
C
      FW = 1.00044 - X * (.23E-4 + .175E-6 * X) + (.39E-5 + X * (.45E-9
     1* X - .285E-7)) * P
      E = H * P / (FW * (H + .62197))
      GO TO 215
 185  E = 4.1650136E-3 * H * T
      GO TO 215
 190  E = H * ESUBS (T)
      GO TO 215
 195  GO TO (200, 205, 210), KP
 200  H = 25.4 * H
 205  H = 1.333224 * H
 210  E = H
C
C     SMITH-WEINTRAUB FORMULATION FOR REFRACTIVITY.
C     SEE PG. 7  BEAN , B. R. AND E. J. DUTTON (1968) , RADIO METEOROLOG
C     (DOVER PUBLICATIONS INC. NEW YORK , N.Y.)
C
 215  W = 373256. * E / T * * 2
      D = 77.6 * P / T
      EN = W + D
      RETURN
      END
```

```
      SUBROUTINE ERF(X,Y,Z)
C     THIS SUBROUTINE UTILIZES AN APPROXIMATION TO THE ERROR FUNCTION.
C        FOR MORE INFO. SEE,  HASTINGS, C.B. JR., APPROXIMATIONS FOR
C        DIGITAL COMPUTERS (1955), PG.169.
C
C.....INPUT
C        X- THE ARGUMENT OF THE ERROR FUNCTION
C
C.....OUTPUT
C        Y- THE VALUE OF THE ERROR FUNCTION FOR THE INPUT X.
C        Z- THE VALUE OF THE COMPLEMENTED ERROR FUNCTION FOR X.
C
      DATA A1,A2,A3,A4,A5/ 0.225836846, -0.252128668, 1.25969513,
     1                   -1.287822453, 0.94064607/
      IF(ABS(X) .LT. 1.E-09)  GO TO 3
C
C     FIND THE ERF FOR X
C
      ETA= 1./(1. + 0.3275911*ABS(X))
       TEMP= (A5*ETA + A4)*ETA + A3
       TEMP= (TEMP*ETA + A2)*ETA + A1
       TEMP= TEMP * ETA
       XSQM= - X**2.
       IF(XSQM .LT. -300.0)  XSQM= -300.0
       TEMP= TEMP * 1.128379167 * EXP(XSQM)
       IF(ABS(TEMP) .LT. 1.E-100)  TEMP= SIGN(1.0E-100,TEMP)
C
C.....DETERMINE IN WHAT INTERVAL THE ARGUMENT LIES IN.
C
C        STATEMENT NUMBER 2 - X LESS THAN ZERO.
C        STATEMENT NUMBER 3 - X EQUALS ZERO.
C        STATEMENT NUMBER 4 - X GREATER THAN ZERO.
C
      IF(X)2,3,4
    2 Y= TEMP - 1.
      Z= 2. - TEMP
      RETURN
    3 Y= 0.0
      Z= 1.0
      RETURN
    4 Y= 1. - TEMP
      Z= TEMP
      RETURN
      END
```

```
      SUBROUTINE ERFCI(Y,XCONF)
C     THIS SUBROUTINE FINDS THE INVERSE OF THE COMPLEMENTED ERROR
C        FUNCTION BY APPLYING A NEWTON-RAPHSONS ITERATION.
C
C.....INPUT
C        Y- THE VALUE OF THE COMPLEMENTED ERROR FUNCTION
C
C.....OUTPUT
C        XCONF- THE ITERATED RESULT
C
      XAPPROX= -0.8862269255 * (Y - 1.0)
C
C     THE ITERATION IS DONE HERE.  AN ARBITRARY ERROR CRITERION OF
C        4.E-06 IS DEMANDED FOR CONVERGENCE.
C
    3 DO 1000 I=1,50
       CALL ERF(XAPPROX,Y1,YAPROX)
       FOFX= Y - YAPROX
       XSQ= - XAPPROX**2.
       IF(XSQ .LT. -300.0)  XSQ= -300.0
       FOFXP= 1.128379167 * EXP(XSQ)
       XOLD= XAPPROX - (FOFX/FOFXP)
       DELTAX= ABS(XAPPROX - XOLD)
       DELTAY= ABS(FOFX)
       TEST= AMAX1(DELTAX,DELTAY)
       IF(TEST .LT. 4.E-06)  GO TO 4
       XAPPROX= XOLD
 1000 CONTINUE
C
C     IF THE ITERATION FAILS AN ERROR MESSAGE IS PRINTED AND THE LAST
C        VALUE OF XAPROX IS SUBSTITUTED IN FOR XCONF.  PROCESSING IS
C        THEN RETURNED TO THE CALLING PROGRAM, IN THIS CASE TO TRUNCN.
C
      WRITE(6,1001)FOFX,FOFXP,XAPPROX,Y

    4 XCONF= XAPPROX
      RETURN

 1001 FORMAT(1X,///1X,46HNON-CONVERGENCE FOR ITERATIVE METHOD IN ERFCI./
     11X,6HFOFX =,E15.7,10X,7HFOFXP =,E15.7,10X,8HXAPROX =,E15.7,10X,3HY
     2 =,E15.7///)

      END
```

```
      SUBROUTINE TRUNCN(TMOD,VTAU,TAU5,TAU95)
C
C     THIS SUBROUTINE USES A TRUNCATED NORMAL DISTRIBUTION TO CALCULATE
C        THE 0.5, 5, 95, AND, THE 99.5 PER CENT CONFIDENCE LEVELS OF
C        ATTENUATION
C
C.........NOTE - THE 0.5 AND 99.5 PER CENT CONFIDENCE LEVELS ARE
C              CALCULATED BUT NOT PASSED BACK TO THE MAIN PROGRAM.
C
C.....INPUT
C        TMOD - MEAN PREDICTED ATTENUATION FOR EACH METHOD
C        VTAU - VARIANCE OF THAT ATTENUATION
C
C.....OUTPUT
C        TAU5 - 5 PER CENT CONFIDENCE LEVEL OF ATTENUATION FOR EACH
C               METHOD
C        TAU95 - 95 PER CENT CONFIDENCE LEVEL OF ATTENUATION FOR EACH
C                METHOD
C
      DIMENSION VTAU(12,4), TMOD(12,4), TAU5(12,4), TAU95(12,4)
      DO 1000 METHOD=1,4
       DO 750 I=1,11
        IF(VTAU(I,METHOD) .NE. 0.0)  GO TO 1
C
C.....SET CONFIDENCE LEVELS OF ATTENUATION TO ZERO IF VTAU IS ZERO.
C
         C05= 0.0
         TAU5(I,METHOD)= 0.0
         TAU95(I,METHOD)= 0.0
         C995= 0.0
         GO TO 750
C
C.....DETERMINE CONFIDENCE LEVELS OF ATTENUATION IF VTAU IS NON-ZERO
C
    1   RT2TAU= SQRT(2. * VTAU(I,METHOD))
        X= TMOD(I,METHOD)/RT2TAU
        CALL ERF(X,Y,Z)
        V= 2./(1. + Y)
        X= 1.99/V
        CALL ERFCI(X,XPT5)
        X= 1.9/V
        CALL ERFCI(X,X5)
        X= 0.1/V
        CALL ERFCI(X,X95)
        X= 0.01/V
        CALL ERFCI(X,X99PT5)
        C05= TMOD(I,METHOD) + RT2TAU*XPT5
        TAU5(I,METHOD)= TMOD(I,METHOD) + RT2TAU*X5
        TAU95(I,METHOD)= TMOD(I,METHOD) + RT2TAU*X95
        C995= TMOD(I,METHOD) + RT2TAU*X99PT5
  750  CONTINUE
 1000 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FARM (DLTN, RESWAV, ACTWAV, FORMA, FORMP)
C
C     THIS ROUTINE COMPUTES LINE SHAPES AND FORMS ASSOCIATED WITH CAL-
C     CULATIONS MADE IN TOPOXY.
C
      X = RESWAV - ACTWAV
      X2 = X * X
      Y = RESWAV + ACTWAV
      Y2 = Y * Y
      D2 = DLTN * DLTN
      FORM1 = X2 + D2
      FORM1 = 1. / FORM1
      FORM2 = Y2 + D2
      FORM2 = 1. / FORM2
      FORMP=(D2/ACTWAV+(RESWAV/ACTWAV)*X)*FORM1+(D2/ACTWAV+(RESWAV/ACTWA
     1V)*Y)*FORM2
      FORMA = DLTN * (FORM1 + FORM2)
      RETURN
      END
```

```
      SUBROUTINE FREQ
C
C     THIS ROUTINE COMPUTES LINE SHAPES AND FORMS ASSOCIATED WITH CAL-
C     CULATIONS MADE IN TOPOXY.
C
C     NOTE - SUBROUTINE FREQ USES FUNCTIONS RSLMD1 AND RSLMD2.
C
      COMMON /BLOCK2 /PMUPL (49), PMUM (49), PMUNOT (49), RSRLM1 (49), R
     1SRLM2 (49)
      PMU = - 252.72
      DO 125 K = 1, 49, 2
      PK = K
      IF (K - 1)105, 110, 115
  105 STOP
  110 FACTOR = - 1.0
      GO TO 120
  115 FACTOR = 1.0
  120 CONTINUE
      PLAMDA = 59501.6 + .0575 * PK * (PK + 1.0)
      B = 43101.6 - .14 * PK * (PK + 1.0)
      RSRLM1 (K) = RSLMD1 (PK, PLAMDA, B, PMU)
      RSRLM2(K) = RSLMD2 (PK, PLAMDA, B, PMU, FACTOR)
  125 CONTINUE
      RETURN
      END
```

```
      FUNCTION ESUBS (T)
C
C     THIS SUBROUTINE CALCULATES SATURATION VAPOR PRESSURE OF WATER IN
C     AIR AT TEMPERATURE T IN DEGREES KELVIN.
C
      X = .05 * (T - 243.)
      Y = 26.461779 - X * (.336222 - (X - 1.) * (.9889E-2 - (X - 2.) * (
     1.144666E-3 + (X - 3.) * .225E-4)))
      ESUBS = EXP (Y - 6594.4074 / T)
      IF((T-283.).LE.0.0) GO TO 105
      ESUBS = ESUBS + (100. - (T-293.)**2.) * 8.E-6
  105 RETURN
      END
```

```
      FUNCTION EXTERP (N, P, X, Y)
C
C     THIS FUNCTION DOES EXPONENTIAL INTERPOLATION AND EXTRAPOLATION.
C
C.....INPUT
C
C     N=NUMBER OF DATA POINTS, (X,Y), TO BE USED IN INTERPOLATION.
C
C     P=X VALUE THAT PRODUCES INTERPOLATED Y VALUE.
C
      DIMENSION X(75),Y(75)
      IF (N .LT. 2) GO TO 120
      DO 100 I = 2, N
      IF((X(I)-P).GE.0.0) GO TO 105
  100 CONTINUE
  120 CONTINUE
      I = N
  105 IF((Y(I) * Y(I - 1)).GT.0.0) GO TO 115
      EXTERP = (Y(I)-Y(I-1))*(P-X(I-1))/(X(I)-X(I-1))+Y(I-1)
      RETURN
  115 EXTERP = Y (I - 1) * EXP (ALOG (Y (I) / Y (I - 1)) * (P - X (I - 1
     1)) / (X (I) - X (I - 1)))
      RETURN
      END
```

```
      FUNCTION RSLMD1 (PK, FLAMDA, B, PMU)
C
C     THIS ROUTINE COMPUTES LINE SHAPES AND FORMS ASSOCIATED WITH CAL-
C     CULATIONS MADE IN TOPOXY.
C
      Y = B - PMU / 2.
      Y1 = (PK + PK + 3.) * Y
      X = PLAMDA - PMU * (PK + 1.) - Y1 + SQRT (FLAMDA * PLAMDA - (PLAMD
     1A + PLAMDA) * Y + Y1 * Y1)
      RSLMD1 = X / (2.99793E+4)
      RETURN
      END
```

```
      FUNCTION RSLMD2(PK, PLAMDA, B, PMU, FACTOR)
C
C     THIS ROUTINE COMPUTES LINE SHAPES AND FORMS ASSOCIATED WITH CAL-
C     CULATIONS MADE IN TOPOXY.
C
      Y = B - PMU / 2.
      Y1 = (PK + PK - 1.) * Y
      X = PLAMDA + PMU * PK + Y1 - FACTOR * SQRT(PLAMDA * PLAMDA -( PLAM
     1DA + PLAMDA) * Y + Y1 * Y1)
      RSLMD2 = X / (2.99793E+4)
      RETURN
      END
```

```
      FUNCTION GAMMA(FREQ)
C
C       FREQ IS FREQUENCY IN GHZ BETWEEN 7 GHZ AND 100 GHZ.
C
      DIMENSION F(27),G(27)
C
C       THESE DATA ARE TAKEN FROM THE CCIR CURVES OF ATTENUATION PER KM.
C
      DATA((F(L),L=1,27)= 7., 7.3, 7.9, 8.4, 8.8, 9.3, 10., 10.5, 12.,
     1      13., 14., 15., 16.4, 17.5, 18.5, 20., 22.3, 26., 29., 32.1,
     2      35., 41., 52., 58., 70., 78., 100.)
      DATA((G(L),L=1,27)= .002, .0025, .003, .004, .005, .0065, .008,
     1      .01, .015, .02, .025, .03, .04, .05, .06, .08, .1, .15, .2,
     2      .25, .3, .4, .5, .6, .8, 1., 1.05)
C
C       GAMMA IS RAIN ATTENUATION COEFFICIENT AT FREQ IN DB/KM/MM/HR.
C
      GAMMA=TERP(28,FREQ,F,G)
      RETURN
      END


      FUNCTION TERP (N, P, X, Y)
C
C.....THIS FUNCTION DOES LINEAR INTERPOLATION AND EXTRAPOLATION.
C
C.....INPUT
C
C     N= NUMBER OF DATA POINTS (X,Y) TO BE USED IN INTERPOLATION.
C     P= X VALUE THAT PRODUCES INTERPOLATED Y VALUE .
C
      DIMENSION X (50), Y (50)
      DO 100 I = 2, N
      IF (P - X (I))105, 110, 100
  100 CONTINUE
      I = N
  105 TERP = Y (I - 1) + (Y (I) - Y (I - 1)) * (P - X (I - 1)) / (X (I)
     1- X (I - 1))
      RETURN
  110 TERP = Y (I)
      RETURN
      END
```

```
      SUBROUTINE TABLUS(XLAT,XLON,ELEV,P,T,RH,EM,D,U,EMAX,IFLAG)
C
C     SUBROUTINE TABLUS SPECIFIES ALL METEOROLOGICAL DATA NEEDED FOR
C        PROPER PROGRAM EXECUTION.  IF THE DATA IS ALREADY SPECIFIED
C        THIS IS GIVEN PRIORITY AND IS RETAINED.  HOWEVER, IF THE DATA
C        IS UNSPECIFIED AN INTERPOLATION IS DONE FOR THIS DATA BY MEANS
C        OF IDBVIP.  THUS, TABLUS IS THE MAIN INTERFACE TO IDBVIP AND
C        DETERMINES ALL PARAMETERS NECESSARY FOR ITS PROPER EXECUTION
C        SUBROUTINES THAT INTERFACE WITH TABLUS FOLLOW
C
C        TRIPART - DETERMINES ALL NECESSARY PARAMETERS FOR IDBVIP
C                  EXECUTION.  IT DETERMINES IN WHICH OF THE 3 AREAS
C                  IN THE U.S. THE POINT LIES.
C
C        SORT - DETERMINES THE CLOSEST SET OF DATA POINTS UPON WHICH THE
C               INTERPOLATION IS BASED.
C
C        CLSPT - FINDS IF ANY OF OUR DATA POINTS CONTAINED WITHIN BLOCK
C                DATA TABLES ARE WITHIN .1 DEGREE.  IF SO, ANY DATA THAT
C                IS UNKNOWN IS SUBSTITUTED FOR AND NO INTERPOLATION IS
C                DONE.
C
C        IDBVIP - THE MAIN SUBROUTINE FOR THE PACKAGE THAT DOES THE
C                 INTERPOLATION.  SEE IDBVIP FOR MORE INFO.
C
C        BLOCK DATA TABLES - CONTAINS THE DATA BASE UPON WHICH THESE
C                            DATA POINTS ARE DRAWN FROM.
C
C
C.....INPUT
C        XLAT - STATION LATITUDE IN DD.MM.SS AT WHICH DATA IS DESIRED
C        XLON - STATION LONGITUDE IN DD.MM.SS AT WHICH DATA IS DESIRED
C        ELEV - ELEVATION OF SAID STATION
C
C........NOTE - ANY OR ALL OF THE FOLLOWING MAY BE UNSPECIFIED
C
C        P - PRESSURE AT STATION (MILLIBARS)
C        T - TEMPERATURE AT STATION (DEGREES CENTIGRADE)
C        RH - RELATIVE HUMIDITY AT STATION (DECIMAL FRACTION)
C        EM - AVERAGE ANNUAL PRECIPITATION (MM.)
C        D - AVERAGE NUMBER OF DAYS WITH PRECIPITATION GREATER THAN .25
C            MM.
C        U - NUMBER OF THUNDERSTORM DAYS
C        EMAX - GREATEST MONTHLY PRECIPITATION RECORDED IN 30 YEARS
C
C.....DESCRIPTION OF MAJOR VARIABLES
C
C        DECLAT, DECLON - ARRAYS CONTAINING POSITIONS OF THE CLOSEST SET
C                         OF DATA POINTS.
C
C        PRESS (P), TEMP (T), RELHUM (RH), MM (M), DD (D), UU (U),
C        EMX (EMAX) - ARRAYS CONTAINING THE METEOROLOGICAL DATA OF THE
C                     CLOSEST SET OF DATA POINTS .  IN PARENS IS WHAT
C                     IS BEING INTERPOLATED FOR.  I.E. IF P IS UNKNOWN,
C                     PRESS IS USED TO BASE THE INTERPOLATION ON.
C
C        IWICH - INTEGER ARRAY CONTAINING SUBSCRIPTS OF THE CLOSEST SET
C                OF DATA POINTS
C
C        IWK, WK - WORK ARRAYS REQUIRED BY IDBVIP.  THESE ARE
C                  DIMENSIONED AT A MAXIMUM OF 20 POINTS TO BASE THE
C                  INTERPOLATION ON.  SEE IDBVIP FOR MORE INFO.
C
C        IFLAG - INTEGER ARRAY SPECIFYING WHETHER EM, D, U, OR EMAX WERE
```

```
C                INTERPOLATED FOR.
C
C        DCXLAT, DCXLON - DECIMAL POSITION OF STATION AT WHICH DATA IS
C                         DESIRED.
C
C        ICLOSE - INTEGER VARIABLE CONTAINING CLOSEST POINT THAT IS
C                 WITHIN .1 DEGREE OF THE STATION AT WHICH DATA IS
C                 DESIRED
C
C        NDP - NUMBER OF DATA POINTS USED IN INTERPOLATION.  DEPENDS ON
C              THE PARTITION THE INTERPOLATED POINT IS IN.  I.E.
C              FOR HAWAII - NDP= 4
C              FOR ALASKA - NDP= 26
C              FOR THE CONTINENTAL U.S. - NDP= 329
C
C        NCP - NUMBER OF DATA POINTS USED TO ESTIMATE PARTIAL
C              DERIVATIVES - SEE IDBVIP
C
C
      DIMENSION PRESS(20), TEMP(20), RELHUM(20), DD(20), UU(20), EMX(20)
      DIMENSION DECLAT(20), DECLON(20), IFLAG(4), IWICH(20)
      DIMENSION IWK(1551), WK(160)
      COMMON/DATPT/ DATAPT(359,10)
      REAL MM(20)
C
C.....DATA STATEMENT CONTAINING ROUNDING FACTOR FOR ELEVATION.
C        ELEVATION IS ASSUMED ACCURATE TO MAP ACCURACY - 35 M.
C
      DATA CONTUR/ 35.0/
C
C.....FUNCTION TO CONVERT DD.MM.SS TO DECIMAL DEGREES
C
      DECIML(X)= FLOAT(INT(X)) + (X - FLOAT(INT(X)))/0.6
C
C.....INITIALIZE IFLAG
C
      IFLAG(1)= 0
      IFLAG(2)= 0
      IFLAG(3)= 0
      IFLAG(4)= 0
C
C.....TEST TO SEE IF ALL THE DATA IS SPECIFIED
C
       TABS= ABS(T)
      TEST= AMIN1(P,TABS,RH,EM,D,U,EMAX)
      IF(TEST .NE. 0.0)  RETURN
C
C.....ROUND ELEVATION TO CLOSEST CONTOUR INTERVAL
C
        E1= ELEV/CONTUR
        E2= AINT(E1)
        E3= AINT(2.*(E1 - E2))
      ELV= (E2 + E3) * CONTUR
C
C.....CONVERT INTERPOLATED STATION LOCATION TO DECIMAL DEGREES.
C
      DCXLAT= DECIML(XLAT)
      DCXLON= DECIML(XLON)
C
C.....CALL TRIPART TO GET ALL NEEDED INFO. AND DATA FOR THE INTERP.
C
      CALL TRIPART(NDP,NCP,DCXLAT,DCXLON,IWICH,ICLOSE)
C
C.....TEST TO SEE IF INTERPOLATED STATION LIES WITHIN .1 DEGREE OF A
```

```
C        DATA STATION
C
      IF(ICLOSE .EQ. 0)   GO TO 1
         IF(P .EQ. 0.0)   P= DATAPT(ICLOSE,4)
         IF(T .EQ. 0.0)   T= DATAPT(ICLOSE,5)
         IF(RH .EQ. 0.0)   RH= DATAPT(ICLOSE,6)
         IF(EM .EQ. 0.0)   EM= DATAPT(ICLOSE,7)
         IF(D .EQ. 0.0)   D= DATAPT(ICLOSE,8)
         IF(U .EQ. 0.0)   U= DATAPT(ICLOSE,9)
         IF(EMAX .EQ. 0.0)   EMAX= DATAPT(ICLOSE,10)
      RETURN
C
C.....IF SOME DATA IS UNSPECIFIED AND STATION LIES OUTSIDE OF .1 DEGREE
C        OF A DATA STATION, PROCEED WITH INTERPOLATION.
C
C.....NOTE - PRESSURE IS REDUCED TO SEA-LEVEL FOR A MORE ACCURATE
C        INTERPOLATION VIA EXP(ARG)
C
    1 DO 1000 I=1,NDP
        DECLAT(I)= DATAPT(IWICH(I),1)
        DECLON(I)= DATAPT(IWICH(I),2)
         ARG= 9.8 * DATAPT(IWICH(I),3)/(287.04 * (273.16 +
     1        DATAPT(IWICH(I),5)))
        PRESS(I)= DATAPT(IWICH(I),4) * EXP(ARG)
        TEMP(I)= DATAPT(IWICH(I),5)
        RELHUM(I)= DATAPT(IWICH(I),6)
        MM(I)= DATAPT(IWICH(I),7)
        DD(I)= DATAPT(IWICH(I),8)
        UU(I)= DATAPT(IWICH(I),9)
        EMX(I)= DATAPT(IWICH(I),10)
 1000 CONTINUE
C
C.....THE INTERPOLATION IS BEGUN HERE WITH AN INITIAL CALL TO IDBVIP TO
C        INTERPOLATE EMAX.  THUS, ANY OF THE ABOVE METEOROLOGICAL DATA
C        THAT IS UNKNOWN WILL BE INTERPOLATED FOR.  IN THE CASE OF EM,
C        D, U, OR EMAX BEING UNKNOWN A FLAG- IFLAG, IS SET SPECIFYING SO
C
      CALL IDBVIP(1,NCP,NDP,DECLAT,DECLON,EMX,DCXLAT,DCXLON,EMXE,IWK,WK)
      IF(EMAX .NE. 0.0)   GO TO 2
        EMAX= EMXE
        IFLAG(4)= -1
C
C.....IF T IS UNKNOWN INTERPOLATE FOR IT HERE.
C
    2 IF(T .NE. 0.0)   GO TO 3
        CALL IDBVIP(3,NCP,NDP,DECLAT,DECLON,TEMP,DCXLAT,DCXLON,T,IWK,WK)
C
C.....IF P IS UNKNOWN INTERPOLATE FOR IT HERE AND THEN RE-EVALUATE FROM
C        PSEUDO-SEA-LEVEL TO ELV.
C
    3 IF(P .NE. 0.0)   GO TO 4
        CALL IDBVIP(3,NCP,NDP,DECLAT,DECLON,PRESS,DCXLAT,DCXLON,P,IWK,WK)
         ARG= -9.8 * ELV/(287.04 * (273.16 + T))
        P= P * EXP(ARG)
C
C.....IF RH IS UNKNOWN INTERPOLATE FOR IT HERE
C
    4 IF(RH .NE. 0.0)   GO TO 5
      CALL IDBVIP(3,NCP,NDP,DECLAT,DECLON,RELHUM,DCXLAT,DCXLON,RH,
     1             IWK,WK)
C
C.....IF EM IS UNKNOWN INTERPOLATE FOR IT HERE
C
```

```
    5  IF(EM .NE. 0.0)   GO TO 6
       CALL IDBVIP(3,NCP,NDP,DECLAT,DECLON,MM,DCXLAT,DCXLON,EM,IWK,WK)
       IFLAG(1)= -1
    6  IF(D .NE. 0.0)   GO TO 7
C
C.....IF D IS UNKNOWN INTERPOLATE FOR IT HERE
C
       CALL IDBVIP(3,NCP,NDP,DECLAT,DECLON,DD,DCXLAT,DCXLON,D,IWK,WK)
       IFLAG(2)= -1
C
C.....IF U IS UNKNOWN INTERPOLATE FOR IT HERE
C
    7  IF(U .NE. 0.0)   RETURN
       CALL IDBVIP(3,NCP,NDP,DECLAT,DECLON,UU,DCXLAT,DCXLON,U,IWK,WK)
       IFLAG(3)= -1
       RETURN
       END
```

```
      SUBROUTINE TRIPART(NDP,NCP,DCXLAT,DCXLON,IWICH,ICLOSE)
C
C     THIS ROUTINE FINDS WHICH OF THE 3 PARTITIONS OF THE U.S. CONTAINS
C        THE INTERPOLATED POINT.  IT THEN INITIALIZES VARIABLES- NCP AND
C        NDP, NEEDED FOR PROPER EXCUTION OF IDBVIP-(AKIMA,1977).  IT
C        ALSO INTERFACES WITH TWO SUBROUTINES - SORT AND CLSPT.
C
C        SORT - THIS FINDS THE CLOSEST SET OF DATA POINTS.
C
C        CLSPT - THIS DETERMINES IF ANY DATA POINTS LIE WITHIN .1
C              DEGREE OF THE INTERPOLATED STATION.
C
C     THE CRITERION FOR DETERMINATION OF WHICH PARTITION IS ROUGHLY THIS
C
C        FOR ALASKA
C        LATITUDE GREATER THAN 50. DEGREES
C        130. LT LONGITUDE LT 150. DEGREES
C
C        FOR HAWAII
C        18.5 LT LATITUDE 22.5 DEGREES
C        150. LT LONGITUDE LT 160. DEGREES
C
C        FOR THE CONTINENTAL U.S.
C        24.5 LT LATITUDE LT 50. DEGREES
C        66. LT LONGITUDE LT 126. DEGREES
C
C.....NOTE - IF THE POINT DOES NOT LIE IN ONE OF THESE PARTITIONS, THE
C        CLOSEST 20 DATA POINTS ARE FOUND AND THESE ARE USED FOR THE
C        INTERPOLATION.
C
C.....INPUT
C        DCXLAT, DCXLON - DECIMAL POSITION OF THE STATION
C
C
C.....OUTPUT
C
C        NDP - NUMBER OF DATA POINTS USED FOR INTERPOLATION
C        NCP - NUMBER OF DATA POINTS USED FOR ESTIMATING PARTIALS
C        IWICH - INTEGER ARRAY CONTAINING SUBSCRIPTS OF CLOSEST POINTS
C        ICLOSE - INTEGER VARIABLE CONTAINING SUBSCRIPT OF CLOSEST DATA
C                 POINT WITHIN .1 DEGREE OF THE UNKNOWN STATION,
C                 OTHERWISE, IT IS SET TO ZERO.
C
C     VARIABLES OF INTEREST IN THE SUBROUTINE
C
C        ISTART - SPECIFIES WHERE THE DATA FOR THAT PARTITION STARTS IN
C                 DATAPT.
C        CLOSE - ARRAY HOLDING DISTANCES OF CLOSEST SET OF DATA POINTS.
C        NDP1 - NUMBER OF DATA POINTS THAT WILL BE USED FOR THE
C               INTERPOLATION BASE.
C        NDP - NUMBER OF DATA POINTS IN EACH PARTITION.  THE NDP1 DATA
C              POINTS WILL BE CONTAINED IN THIS PARTITION.
C
      DIMENSION CLOSE(20), IWICH(20)
      COMMON/DATPT/ DATAPT(359,10)
C
C.....INITIALIZE ICLOSE
C
      ICLOSE=0
C
C.....DETERMINE WHETHER DESIRED POINT LIES WITHIN THE ALASKAN AREA.
C
      IF(DCXLAT .LT. 50.)  GO TO 1
       IC= 10H  ALASKA
```

```
      NDP= 355
      NDP1= 20
      NCP= 4
      ISTART= 330
      IF(DCXLON .GT. 130.)  99,199
C
C.....DETERMINE WHETHER THE DESIRED POINT LIES WITHIN THE HAWAIIAN AREA
C
    1 IF(DCXLON .LT. 150.)   GO TO 2
      ID= 10H  HAWAII
      NDP= 359
      NDP1= 4
      NCP= 3
      ISTART= 356
      IF(DCXLON .GT. 160.)  GO TO 199
      IF((DCXLAT .GT. 18.5)  .AND.  (DCXLAT .LT. 22.5))  99,199
C
C.....POINT LIES WITHIN THE CONTINENTAL U.S. AREA
C
    2 ID= 10HCONT. U.S.
      NDP= 329
      NDP1= 20
      NCP= 4
      ISTART= 1
      IF(DCXLAT .LT. 24.5)  GO TO 199
      IF((DCXLON .LT. 126.)  .AND.  (DCXLON .GT. 66.))  99,199
C
C.....IF THE POINT LIES IN ONE OF THE ABOVE ZONES, PRINT A MESSAGE
C        SAYING SO AND CALL SORT AND CLSPT.  THEN INITIALIZE THE OUTPUT
C        NDP.
C
   99 WRITE(6,100)ID
      CALL SORT(DCXLAT,DCXLON,NDP,IWICH,NDP1,CLOSE,ISTART)
      CALL CLSPT(CLOSE,NDP1.IWICH,ICLOSE)
      NDP= NDP1
      RETURN
C
C.....DESIRED POINT LIES OUTSIDE OF THE POLITICAL U.S. PRINT A MESSAGE
C        SAYING SO AND FIND THE 20 CLOSEST DATA POINTS FOR THE
C        INTERPOLATION
C
  199 WRITE(6,200)
      NDP= 359
      NDP1= 20
      ISTART= 1
      CALL SORT(DCXLAT,DCXLON,NDP,IWICH,NDP1,CLOSE,ISTART)
      NDP= NDP1
      RETURN
  100 FORMAT(1X,31HINTERPOLATED POINT LIES IN THE ,A10,6H ZONE.)
  200 FORMAT(1X,96HINTERPOLATED POINT LIES OUTSIDE OF U.S. POLITICAL BOU
     1NDARIES.  PROGRAM CANNOT GUARANTEE RESULTS.)
      END
```

```
      SUBROUTINE CLSPT(CLOSE,NDP1,IWICH,ICLOSE)
C
C     THIS SUBROUTINE DETERMINES IF ANY DATA STATIONS ARE WITHIN .1
C        DEGREE OF THE DESIRED STATION.
C
C.....INPUT
C        CLOSE - ARRAY CONTAINING DISTANCES FROM THE CLOSEST SET OF DATA
C                STATIONS TO THE DESIRED STATION.
C        IWICH - ARRAY CONTAINING THE SUBSCRIPTS OF THE CLOSEST SET OF
C                DATA STATIONS.
C        NDP1 - QUANTITY OF CLOSEST DATA STTATIONS.
C
C.....OUTPUT
C        ICLOSE - IF THERE EXISTS A STATION WITHIN .1 DEGREE OF THE
C                 DESIRED STATION, ICLOSE IS SET TO THAT STATIONS
C                 SUBSCRIPT AND A MESSAGE IS PRINTED.  IF NOT, ICLOSE
C                 REMAINS AT ZERO.
C
      DIMENSION CLOSE(NDP1), IWICH(NDP1), IHOLD(10,2)
      REAL MINDIS
C
C.....DATA STATEMENT THAT CONTAINS A DISTANCE OF APPROXIMATELY .1 DEGREE
C        IN KM. SQUARED
C
      DATA MINDIS/ 7.5E-03/
      KOUNT= 0
      DO 1000 I=1,NDP1
       IF(CLOSE(I) .GT. MINDIS)  GO TO 1000
        KOUNT= KOUNT + 1
        IHOLD(KOUNT,1)= I
        IHOLD(KOUNT,2)= IWICH(I)
 1000 CONTINUE
      IF(KOUNT .EQ. 0)  RETURN
C
C.....AT LEAST ONE STATION FOUND THAT LIES WITHIN .1 DEGREE.  FIND THE
C        CLOSEST.
C
      ICLOSE= IHOLD(1,2)
      CLMIN= CLOSE(IHOLD(1,1))
      DO 1250 I=1,KOUNT
       IF(CLMIN .LE. CLOSE(IHOLD(I,1)))  GO TO 1250
        CLMIN= CLOSE(IHOLD(I,1))
      ICLOSE= IHOLD(I,2)
 1250 CONTINUE
      PRINT 100,ICLOSE
      RETURN
  100 FORMAT(1H ,60HSTATION IS WITHIN ONE TENTH OF A DEGREE FROM A DATA
     1STATION./1H ,60HPROGRAM DEFAULTS TO METEOROLOGICAL DATA FROM STATI
     2ON NUMBER ,I3)
      END
```

```
      SUBROUTINE SORT(DCXLAT,DCXLON,NDP,IWICH,NDP1,CLOSE,ISTART)
C
C     THIS SUBROUTINE IS A SORTING ROUTINE TO FIND THE CLOSEST SET OF
C        DATA POINTS TO THE DESIRED STATION.
C
C.....INPUT
C        DCXLAT, DCXLON - DECIMAL LOCATION OF THE DESIRED STATION
C        NDP - NUMBER OF DATA STATIONS IN EACH PARTITION.
C        NDP1 - QUANTITY OF CLOSEST DATA STATIONS DESIRED FOR
C                 INTERPOLATION.
C        ISTART - WHERE THE DATA BASE STARTS RELATIVE TO THE ARRAY
C                   DATAPT.
C
C.....OUTPUT
C        IWICH - INTEGER ARRAY CONTAINING THE SUBSCRIPTS OF THE CLOSEST
C                  SET OF DATA POINTS.
C        CLOSE - ARRAY CONTAINING THE SQUARED DISTANCES OF THE CLOSEST
C                  SET OF DATA POINTS TO THE DESIRED POINT.
C
      DIMENSION IWICH(NDP1), CLOSE(NDP1)
      COMMON/DATPT/DATAPT(359,10)
      DSQF(X1,Y1,X2,Y2)= (X2 - X1)**2 + (Y2 - Y1)**2
      J1=0
      CLMAX= 0.0
      DO 1000 I=ISTART,NDP
       DSQ= DSQF(DCXLAT,DCXLON,DATAPT(I,1),DATAPT(I,2))
       J1= J1 + 1
       CLOSE(J1)= DSQ
       IWICH(J1)= J1
        IF(DSQ .LE. CLMAX)  GO TO 1
        CLMAX= DSQ
        JMAX= J1
    1   IF(J1 .GE. NDP1)  GO TO 2
 1000 CONTINUE
    2 IMIN= I + 1
       IF(IMIN .GT. NDP)  RETURN
      DO 1500 I=IMIN,NDP
       DSQ= DSQF(DCXLAT,DCXLON,DATAPT(I,1),DATAPT(I,2))
        IF(DSQ .GE. CLMAX)  GO TO 1500
        CLOSE(JMAX)= DSQ
        IWICH(JMAX)= I
        CLMAX= 0.0
         DO 1250 J=1,NDP1
          IF(CLOSE(J) .LE. CLMAX)  GO TO 1250
          CLMAX= CLOSE(J)
          JMAX= J
 1250   CONTINUE
 1500 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE IDBVIP(MD,NCP,NDP,XD,YD,ZD,XI,YI,ZI,IWK,WK)
C THIS SUBROUTINE PERFORMS BIVARIATE INTERPOLATION WHEN THE PRO-
C JECTIONS OF THE DATA POINTS IN THE X-Y PLANE ARE IRREGULARLY
C DISTRIBUTED IN THE PLANE.
C THE INPUT PARAMETERS ARE
C     MD  = MODE OF COMPUTATION (MUST BE 1, 2, OR 3),
C         = 1 FOR NEW NCP AND/OR NEW XD-YD,
C         = 2 FOR OLD NCP, OLD XD-YD, NEW XI-YI,
C         = 3 FOR OLD NCP, OLD XD-YD, OLD XI-YI,
C     NCP = NUMBER OF ADDITIONAL DATA POINTS USED FOR ESTI-
C           MATING PARTIAL DERIVATIVES AT EACH DATA POINT
C           (MUST BE 2 OR GREATER, BUT SMALLER THAN NDP),
C     NDP = NUMBER OF DATA POINTS (MUST BE 4 OR GREATER),
C     XD  = ARRAY OF DIMENSION NDP CONTAINING THE X
C           COORDINATES OF THE DATA POINTS,
C     YD  = ARRAY OF DIMENSION NDP CONTAINING THE Y
C           COORDINATES OF THE DATA POINTS,
C     ZD  = ARRAY OF DIMENSION NDP CONTAINING THE Z
C           COORDINATES OF THE DATA POINTS,
C     XI  = ARRAY OF DIMENSION NIP CONTAINING THE X
C           COORDINATES OF THE OUTPUT POINTS,
C     YI  = ARRAY OF DIMENSION NIP CONTAINING THE Y
C           COORDINATES OF THE OUTPUT POINTS.
C THE OUTPUT PARAMETER IS
C     ZI  = ARRAY OF DIMENSION NIP WHERE INTERPOLATED Z
C           VALUES ARE TO BE STORED.
C THE OTHER PARAMETERS ARE
C     IWK = INTEGER ARRAY OF DIMENSION
C              MAX0(31,27+NCP)*NDP+NIP
C           USED INTERNALLY AS A WORK AREA,
C     WK  = ARRAY OF DIMENSION 8*NDP USED INTERNALLY AS A
C           WORK AREA.
C
C.....NOTE - NIP IS SET TO ONE.
C
C THE VERY FIRST CALL TO THIS SUBROUTINE AND THE CALL WITH A NEW
C NCP VALUE, A NEW NDP VALUE, AND/OR NEW CONTENTS OF THE XD AND
C YD ARRAYS MUST BE MADE WITH MD=1.  THE CALL WITH MD=2 MUST BE
C PRECEDED BY ANOTHER CALL WITH THE SAME NCP AND NDP VALUES AND
C WITH THE SAME CONTENTS OF THE XD AND YD ARRAYS.  THE CALL WITH
C MD=3 MUST BE PRECEDED BY ANOTHER CALL WITH THE SAME NCP, NDP,
C AND NIP VALUES AND WITH THE SAME CONTENTS OF THE XD, YD, XI,
C AND YI ARRAYS.  BETWEEN THE CALL WITH MD=2 OR MD=3 AND ITS
C PRECEDING CALL, THE IWK AND WK ARRAYS MUST NOT BE DISTURBED.
C USE OF A VALUE BETWEEN 3 AND 5 (INCLUSIVE) FOR NCP IS RECOM-
C MENDED UNLESS THERE ARE EVIDENCES THAT DICTATE OTHERWISE.
C THE LUN CONSTANT IN THE DATA INITIALIZATION STATEMENT IS THE
C LOGICAL UNIT NUMBER OF THE STANDARD OUTPUT UNIT AND IS,
C THEREFORE, SYSTEM DEPENDENT.
C THIS SUBROUTINE CALLS THE IDCLDP, IDLCTN, IDPDRV, IDPTIP, AND
C IDTANG SUBROUTINES.
C DECLARATION STATEMENTS
      DIMENSION XD(50),YD(50),ZD(50),IWK(1601),WK(400)
      COMMON/IDLC/NIT
      COMMON/IDPI/ITPV
      DATA  LUN/6/
      DATA NIP/1/
C SETTING OF SOME INPUT PARAMETERS TO LOCAL VARIABLES.
C (FOR MD=1,2,3)
   10 MD0=MD
      NCP0=NCP
      NDP0=NDP
      NIP0=NIP
C ERROR CHECK.  (FOR MD=1,2,3)
```

```
   20 IF(MD0.LT.1.OR.MD0.GT.3)                        GO TO 90
      IF(NCP0.LT.2.OR.NCP0.GE.NDP0)                   GO TO 90
      IF(NDP0.LT.4)                                   GO TO 90
      IF(NIP0.LT.1)                                   GO TO 90
      IF(MD0.GE.2)               GO TO 21
      IWK(1)=NCP0
      IWK(2)=NDP0
      GO TO 22
   21 NCPPV=IWK(1)
      NDPPV=IWK(2)
      IF(NCP0.NE.NCPPV)    GO TO 90
      IF(NDP0.NE.NDPPV)    GO TO 90
   22 IF(MD0.GE.3)         GO TO 23
      IWK(3)=NIP
      GO TO 30
   23 NIPPV=IWK(3)
      IF(NIP0.NE.NIPPV)    GO TO 90
C ALLOCATION OF STORAGE AREAS IN THE IWK ARRAY.  (FOR MD=1,2,3)
   30 JWIPT=16
      JWIWL=6*NDP0+1
      JWIWK=JWIWL
      JWIPL=24*NDP0+1
      JWIWP=30*NDP0+1
      JWIPC=27*NDP0+1
      JWIT0= MAX0(31,27+NCP0)*NDP0 + 1
C TRIANGULATES THE X-Y PLANE.  (FOR MD=1)
   40 IF(MD0.GT.1)    GO TO 50
      CALL IDTANG(NDP0,XD,YD,NT,IWK(JWIPT),NL,IWK(JWIPL),
     1            IWK(JWIWL),IWK(JWIWP),WK)
      IWK(5)=NT
      IWK(6)=NL
      IF(NT.EQ.0)     RETURN
C DETERMINES NCP POINTS CLOSEST TO EACH DATA POINT.  (FOR MD=1)
   50 IF(MD0.GT.1)    GO TO 60
      CALL IDCLDP(NDP0,XD,YD,NCP0,IWK(JWIPC))
      IF(IWK(JWIPC).EQ.0)        RETURN
C LOCATES ALL POINTS AT WHICH INTERPOLATION IS TO BE PERFORMED.
C (FOR MD=1,2)
   60 IF(MD0.EQ.3)    GO TO 70
      NIT=0
        CALL IDLCTN(NDP0,XD,YD,NT,IWK(JWIPT),NL,IWK(JWIPL),XI,YI,
     1              IWK(JWIT0),IWK(JWIWK),WK)
C ESTIMATES PARTIAL DERIVATIVES AT ALL DATA POINTS.
C (FOR MD=1,2,3)
   70 CALL IDPDRV(NDP0,XD,YD,ZD,NCP0,IWK(JWIPC),WK)
C INTERPOLATES THE ZI VALUES.  (FOR MD=1,2,3)
   80 ITPV=0
        CALL IDPTIP(XD,YD,ZD,NT,IWK(JWIPT),NL,IWK(JWIPL),WK,IWK(JWIT0),
     1              XI,YI,ZI)
      RETURN
C ERROR EXIT
   90 WRITE (LUN,2090) MD0,NCP0,NDP0,NIP0
      RETURN
C FORMAT STATEMENT FOR ERROR MESSAGE
 2090 FORMAT(1X/41H ***   IMPROPER INPUT PARAMETER VALUE(S)./
     1   7H   MD =,I4,10X,5HNCP =,I6,10X,5HNDP =,I6,
     2   10X,5HNIP =,I6/
     3   35H ERROR DETECTED IN ROUTINE   IDBVIP/)
      END
```

```
      SUBROUTINE  IDCLDP(NDP,XD,YD,NCP,IPC)
C THIS SUBROUTINE SELECTS SEVERAL DATA POINTS THAT ARE CLOSEST
C TO EACH OF THE DATA POINT.
C THE INPUT PARAMETERS ARE
C     NDP = NUMBER OF DATA POINTS,
C     XD,YD = ARRAYS OF DIMENSION NDP CONTAINING THE X AND Y
C           COORDINATES OF THE DATA POINTS,
C     NCP = NUMBER OF DATA POINTS CLOSEST TO EACH DATA
C           POINTS.
C THE OUTPUT PARAMETER IS
C     IPC = INTEGER ARRAY OF DIMENSION NCP*NDP, WHERE THE
C           POINT NUMBERS OF NCP DATA POINTS CLOSEST TO
C           EACH OF THE NDP DATA POINTS ARE TO BE STORED.
C THIS SUBROUTINE ARBITRARILY SETS A RESTRICTION THAT NCP MUST
C NOT EXCEED 25.
C THE LUN CONSTANT IN THE DATA INITIALIZATION STATEMENT IS THE
C LOGICAL UNIT NUMBER OF THE STANDARD OUTPUT UNIT AND IS,
C THEREFORE, SYSTEM DEPENDENT.
C DECLARATION STATEMENTS
      DIMENSION XD(50),YD(50),IPC(200)
      DIMENSION   DSQ0(25),IPC0(25)
      DATA  NCPMX/25/, LUN/6/
C STATEMENT FUNCTION
      DSQF(U1,V1,U2,V2)=(U2-U1)**2+(V2-V1)**2
C PRELIMINARY PROCESSING
   10 NDP0=NDP
      NCP0=NCP
      IF(NDP0.LT.2)  GO TO 90
      IF(NCP0.LT.1.OR.NCP0.GT.NCPMX.OR.NCP0.GE.NDP0)     GO TO 90
C CALCULATION
   20 DO 59  IP1=1,NDP0
C - SELECTS NCP POINTS.
        X1=XD(IP1)
        Y1=YD(IP1)
        J1=0
        DSQMX=0.0
        DO 22  IP2=1,NDP0
          IF(IP2.EQ.IP1)  GO TO 22
          DSQI=DSQF(X1,Y1,XD(IP2),YD(IP2))
          J1=J1+1
          DSQ0(J1)=DSQI
          IPC0(J1)=IP2
          IF(DSQI.LE.DSQMX)     GO TO 21
          DSQMX=DSQI
          JMX=J1
   21     IF(J1.GE.NCP0)  GO TO 23
   22   CONTINUE
   23   IP2MN=IP2+1
        IF(IP2MN.GT.NDP0)       GO TO 30
        DO 25  IP2=IP2MN,NDP0
          IF(IP2.EQ.IP1)  GO TO 25
          DSQI=DSQF(X1,Y1,XD(IP2),YD(IP2))
          IF(DSQI.GE.DSQMX)     GO TO 25
          DSQ0(JMX)=DSQI
          IPC0(JMX)=IP2
          DSQMX=0.0
          DO 24  J1=1,NCP0
            IF(DSQ0(J1).LE.DSQMX)    GO TO 24
            DSQMX=DSQ0(J1)
            JMX=J1
   24     CONTINUE
   25   CONTINUE
C - CHECKS IF ALL THE NCP+1 POINTS ARE COLLINEAR.
   30   IP2=IPC0(1)
```

```
      DX12=XD(IP2)-X1
      DY12=YD(IP2)-Y1
      DO 31  J3=2,NCP
        IP3=IPC0(J3)
        DX13=XD(IP3)-X1
        DY13=YD(IP3)-Y1
        IF((DY13*DX12-DX13*DY12).NE.0.0)     GO TO 50
   31 CONTINUE
C - SEARCHES FOR THE CLOSEST NONCOLLINEAR POINT.
   40 NCLPT=0
      DO 43  IP3=1,NDP
        IF(IP3.EQ.IP1)         GO TO 43
        DO 41  J4=1,NCP0
          IF(IP3.EQ.IPC0(J4))      GO TO 43
   41   CONTINUE
        DX13=XD(IP3)-X1
        DY13=YD(IP3)-Y1
        IF((DY13*DX12-DX13*DY12).EQ.0.0)     GO TO 43
        DSQI=DSQF(X1,Y1,XD(IP3),YD(IP3))
        IF(NCLPT.EQ.0)         GO TO 42
        IF(DSQI.GE.DSQMN)      GO TO 43
   42   NCLPT=1
        DSQMN=DSQI
        IP3MN=IP3
   43 CONTINUE
      IF(NCLPT.EQ.0)     GO TO 91
      DSQMX=DSQMN
      IPC0(JMX)=IP3MN
C - REPLACES THE LOCAL ARRAY FOR THE OUTPUT ARRAY.
   50 J1=(IP1-1)*NCP0
      DO 51  J2=1,NCP0
        J1=J1+1
        IPC(J1)=IPC0(J2)
   51 CONTINUE
   59 CONTINUE
      RETURN
C ERROR EXIT
   90 WRITE (LUN,2090)
      GO TO 92
   91 WRITE (LUN,2091)
   92 WRITE (LUN,2092)  NDP,NCP0
      IPC(1)=0
      RETURN
C FORMAT STATEMENTS FOR ERROR MESSAGES
 2090 FORMAT(1X/41H ***   IMPROPER INPUT PARAMETER VALUE(S).)
 2091 FORMAT(1X/33H ***   ALL COLLINEAR DATA POINTS.)
 2092 FORMAT(8H   NDP =,I5,5X,5HNCP =,I5/
     1   35H ERROR DETECTED IN ROUTINE   IDCLDP/)
      END
```

```
      SUBROUTINE  IDLCTN(NDP,XD,YD,NT,IPT,NL,IPL,XII,YII,ITI,
     1                   IWK,WK)
C THIS SUBROUTINE LOCATES A POINT, I.E., DETERMINES TO WHAT TRI-
C ANGLE A GIVEN POINT (XII,YII) BELONGS.  WHEN THE GIVEN POINT
C DOES NOT LIE INSIDE THE DATA AREA, THIS SUBROUTINE DETERMINES
C THE BORDER LINE SEGMENT WHEN THE POINT LIES IN AN OUTSIDE
C RECTANGULAR AREA, AND TWO BORDER LINE SEGMENTS WHEN THE POINT
C LIES IN AN OUTSIDE TRIANGULAR AREA.
C THE INPUT PARAMETERS ARE
C     NDP = NUMBER OF DATA POINTS,
C     XD,YD = ARRAYS OF DIMENSION NDP CONTAINING THE X AND Y
C             COORDINATES OF THE DATA POINTS,
C     NT  = NUMBER OF TRIANGLES,
C     IPT = INTEGER ARRAY OF DIMENSION 3*NT CONTAINING THE
C             POINT NUMBERS OF THE VERTEXES OF THE TRIANGLES,
C     NL  = NUMBER OF BORDER LINE SEGMENTS,
C     IPL = INTEGER ARRAY OF DIMENSION 3*NL CONTAINING THE
C             POINT NUMBERS OF THE END POINTS OF THE BORDER
C             LINE SEGMENTS AND THEIR RESPECTIVE TRIANGLE
C             NUMBERS,
C     XII,YII = X AND Y COORDINATES OF THE POINT TO BE
C             LOCATED.
C THE OUTPUT PARAMETER IS
C     ITI = TRIANGLE NUMBER, WHEN THE POINT IS INSIDE THE
C             DATA AREA, OR
C             TWO BORDER LINE SEGMENT NUMBERS, IL1 AND IL2,
C             CODED TO IL1*(NT+NL)+IL2, WHEN THE POINT IS
C             OUTSIDE THE DATA AREA.
C THE OTHER PARAMETERS ARE
C     IWK = INTEGER ARRAY OF DIMENSION 18*NDP USED INTER-
C             NALLY AS A WORK AREA,
C     WK  = ARRAY OF DIMENSION 8*NDP USED INTERNALLY AS A
C             WORK AREA.
C DECLARATION STATEMENTS
      DIMENSION XD(50),YD(50),IPT(285),IPL(300),IWK(900),WK(400)
      DIMENSION   NTSC(9),IDSC(9)
      COMMON/IDLC/NIT
C STATEMENT FUNCTION
      SIDE(U1,V1,U2,V2,U3,V3)=(V3-V1)*(U2-U1)-(U3-U1)*(V2-V1)
C PRELIMINARY PROCESSING
   10 NDP0=NDP
      NT0=NT
      NL0=NL
      NTL=NT0+NL0
      X0=XII
      Y0=YII
C PROCESSING FOR A NEW SET OF DATA POINTS
   20 IF(NIT.NE.0)    GO TO 30
      NIT=1
C - DIVIDES THE X-Y PLANE INTO NINE RECTANGULAR SECTIONS.
      XMN=XD(1)
      XMX=XMN
      YMN=YD(1)
      YMX=YMN
      DO 21  IDP=2,NDP0
        XI=XD(IDP)
        YI=YD(IDP)
        IF(XI.LT.XMN)      XMN=XI
        IF(XI.GT.XMX)      XMX=XI
        IF(YI.LT.YMN)      YMN=YI
        IF(YI.GT.YMX)      YMX=YI
   21 CONTINUE
      XS1=(XMN+XMN+XMX)/3.0
      XS2=(XMN+XMX+XMX)/3.0
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      YS1=(YMN+YMN+YMX)/3.0
      YS2=(YMN+YMX+YMX)/3.0
C - DETERMINES AND STORES IN THE IWK ARRAY TRIANGLE NUMBERS OF
C - THE TRIANGLES ASSOCIATED WITH EACH OF THE NINE SECTIONS.
      DO 22  ISC=1,9
        NTSC(ISC)=0
        IDSC(ISC)=0
   22 CONTINUE
      ITOT3=0
      JWK=0
      DO 27  ITO=1,NTO
        ITOT3=ITOT3+3
        I1=IPT(ITOT3-2)
        I2=IPT(ITOT3-1)
        I3=IPT(ITOT3)
        XMN=AMIN1(XD(I1),XD(I2),XD(I3))
        XMX=AMAX1(XD(I1),XD(I2),XD(I3))
        YMN=AMIN1(YD(I1),YD(I2),YD(I3))
        YMX=AMAX1(YD(I1),YD(I2),YD(I3))
        IF(YMN.GT.YS1)                    GO TO 23
        IF(XMN.LE.XS1)                    IDSC(1)=1
        IF(XMX.GE.XS1.AND.XMN.LE.XS2)     IDSC(2)=1
        IF(XMX.GE.XS2)                    IDSC(3)=1
   23   IF(YMX.LT.YS1.OR.YMN.GT.YS2)      GO TO 24
        IF(XMN.LE.XS1)                    IDSC(4)=1
        IF(XMX.GE.XS1.AND.XMN.LE.XS2)     IDSC(5)=1
        IF(XMX.GE.XS2)                    IDSC(6)=1
   24   IF(YMX.LT.YS2)                    GO TO 25
        IF(XMN.LE.XS1)                    IDSC(7)=1
        IF(XMX.GE.XS1.AND.XMN.LE.XS2)     IDSC(8)=1
        IF(XMX.GE.XS2)                    IDSC(9)=1
   25   DO 26  ISC=1,9
          IF(IDSC(ISC).EQ.0)     GO TO 26
          JIWK=9*NTSC(ISC)+ISC
          IWK(JIWK)=ITO
          NTSC(ISC)=NTSC(ISC)+1
          IDSC(ISC)=0
   26   CONTINUE
C - STORES IN THE WK ARRAY THE MINIMUM AND MAXIMUM OF THE X AND
C - Y COORDINATE VALUES FOR EACH OF THE TRIANGLE.
        JWK=JWK+4
        WK(JWK-3)=XMN
        WK(JWK-2)=XMX
        WK(JWK-1)=YMN
        WK(JWK)  =YMX
   27 CONTINUE
      GO TO 60
C CHECKS IF IN THE SAME TRIANGLE AS PREVIOUS.
   30 ITO=ITIPV
      IF(ITO.GT.NTO)       GO TO 40
      ITOT3=ITO*3
      IP1=IPT(ITOT3-2)
      X1=XD(IP1)
      Y1=YD(IP1)
      IP2=IPT(ITOT3-1)
      X2=XD(IP2)
      Y2=YD(IP2)
      IF(SIDE(X1,Y1,X2,Y2,X0,Y0).LT.0.0)          GO TO 60
      IP3=IPT(ITOT3)
      X3=XD(IP3)
      Y3=YD(IP3)
      IF(SIDE(X2,Y2,X3,Y3,X0,Y0).LT.0.0)          GO TO 50
      IF(SIDE(X3,Y3,X1,Y1,X0,Y0).LT.0.0)          GO TO 50
      GO TO 80
```

```
C CHECKS IF ON THE SAME BORDER LINE SEGMENT.
   40 IL1=IT0/NTL
      IL2=IT0-IL1*NTL
      IL1T3=IL1*3
      IP1=IPL(IL1T3-2)
      X1=XD(IP1)
      Y1=YD(IP1)
      IP2=IPL(IL1T3-1)
      X2=XD(IP2)
      Y2=YD(IP2)
      DX02=X0-X2
      DY02=Y0-Y2
      DX21=X2-X1
      DY21=Y2-Y1
      CS0221=DX02*DX21+DY02*DY21
      IF(IL2.NE.IL1)       GO TO 50
      IF(CS0221.GT.0.0)    GO TO 60
      DX01=X0-X1
      DY01=Y0-Y1
      IF(DY01*DX21-DX01*DY21.GT.0.0)      GO TO 60
      IF(DX01*DX21+DY01*DY21.LT.0.0)      GO TO 60
      GO TO 80
C CHECKS IF BETWEEN THE SAME TWO BORDER LINE SEGMENTS.
   50 IF(CS0221.LT.0.0)    GO TO 60
      IP3=IPL(3*IL2-1)
      X3=XD(IP3)
      Y3=YD(IP3)
      DX32=X3-X2
      DY32=Y3-Y2
      IF(DX02*DX32+DY02*DY32.LE.0.0)      GO TO 80
C LOCATES INSIDE THE DATA AREA.
C - DETERMINES THE SECTION IN WHICH THE POINT IN QUESTION LIES.
   60 ISC=1
      IF(X0.GE.XS1)        ISC=ISC+1
      IF(X0.GE.XS2)        ISC=ISC+1
      IF(Y0.GE.YS1)        ISC=ISC+3
      IF(Y0.GE.YS2)        ISC=ISC+3
C - SEARCHES THROUGH THE TRIANGLES ASSOCIATED WITH THE SECTION.
      NTSCI=NTSC(ISC)
      IF(NTSCI.LE.0)       GO TO 70
      JIWK=-9+ISC
      DO 61  ITSC=1,NTSCI
        JIWK=JIWK+9
        IT0=IWK(JIWK)
        JWK=IT0*4
        IF(X0.LT.WK(JWK-3))     GO TO 61
        IF(X0.GT.WK(JWK-2))     GO TO 61
        IF(Y0.LT.WK(JWK-1))     GO TO 61
        IF(Y0.GT.WK(JWK))       GO TO 61
        IT0T3=IT0*3
        IP1=IPT(IT0T3-2)
        X1=XD(IP1)
        Y1=YD(IP1)
        IP2=IPT(IT0T3-1)
        X2=XD(IP2)
        Y2=YD(IP2)
        IF(SIDE(X1,Y1,X2,Y2,X0,Y0).LT.0.0)      GO TO 61
        IP3=IPT(IT0T3)
        X3=XD(IP3)
        Y3=YD(IP3)
        IF(SIDE(X2,Y2,X3,Y3,X0,Y0).LT.0.0)      GO TO 61
        IF(SIDE(X3,Y3,X1,Y1,X0,Y0).LT.0.0)      GO TO 61
        GO TO 80
   61 CONTINUE
```

```
C LOCATES OUTSIDE THE DATA AREA.
   70 NL0T3=NL0*3
      IP1=IPL(NL0T3-2)
      X1=XD(IP1)
      Y1=YD(IP1)
      IP2=IPL(NL0T3-1)
      X2=XD(IP2)
      Y2=YD(IP2)
      DX02=X0-X2
      DY02=Y0-Y2
      DX21=X2-X1
      DY21=Y2-Y1
      CS0221=DX02*DX21+DY02*DY21
      DO 72  IL2=1,NL0
        X1=X2
        Y1=Y2
        DX01=DX02
        DY01=DY02
        CSPV=CS0221
        IP2=IPL(3*IL2-1)
        X2=XD(IP2)
        Y2=YD(IP2)
        DX02=X0-X2
        DY02=Y0-Y2
        DX21=X2-X1
        DY21=Y2-Y1
        CS0221=DX02*DX21+DY02*DY21
        IF(CS0221.GT.0.0)          GO TO 72
        IF(DX01*DX21+DY01*DY21.LT.0.0)    GO TO 71
        IF(DY01*DX21-DX01*DY21.LE.0.0)    GO TO 74
        GO TO 72
   71   IF(CSPV.GT.0.0)            GO TO 73
   72 CONTINUE
      IL2=1
   73 IL1=IL2-1
      IF(IL1.EQ.0)    IL1=NL
      GO TO 75
   74 IL1=IL2
   75 IT0=IL1*NTL+IL2
C NORMAL EXIT
   80 ITI=IT0
      ITIPV=IT0
      RETURN
      END
```

```
      SUBROUTINE  IDPDRV(NDP,XD,YD,ZD,NCP,IPC,PD)
C THIS SUBROUTINE ESTIMATES PARTIAL DERIVATIVES OF THE FIRST AND
C SECOND ORDER AT THE DATA POINTS.
C THE INPUT PARAMETERS ARE
C     NDP = NUMBER OF DATA POINTS,
C     XD,YD,ZD = ARRAYS OF DIMENSION NDP CONTAINING THE X,
C           Y, AND Z COORDINATES OF THE DATA POINTS,
C     NCP = NUMBER OF ADDITIONAL DATA POINTS USED FOR ESTI-
C           MATING PARTIAL DERIVATIVES AT EACH DATA POINT,
C     IPC = INTEGER ARRAY OF DIMENSION NCP*NDP CONTAINING
C           THE POINT NUMBERS OF NCP DATA POINTS CLOSEST TO
C           EACH OF THE NDP DATA POINTS.
C THE OUTPUT PARAMETER IS
C     PD  = ARRAY OF DIMENSION 5*NDP, WHERE THE ESTIMATED
C           ZX, ZY, ZXX, ZXY, AND ZYY VALUES AT THE DATA
C           POINTS ARE TO BE STORED.
C DECLARATION STATEMENTS
      DIMENSION XD(50),YD(50),ZD(50),IPC(200),PD(250)
      REAL        NMX,NMY,NMZ,NMXX,NMXY,NMYX,NMYY
C PRELIMINARY PROCESSING
   10 NDP0=NDP
      NCP0=NCP
      NCPM1=NCP0-1
C ESTIMATION OF ZX AND ZY
   20 DO 24  IP0=1,NDP0
        X0=XD(IP0)
        Y0=YD(IP0)
        Z0=ZD(IP0)
        NMX=0.0
        NMY=0.0
        NMZ=0.0
        JIPC0=NCP0*(IP0-1)
        DO 23  IC1=1,NCPM1
          JIPC=JIPC0+IC1
          IPI=IPC(JIPC)
          DX1=XD(IPI)-X0
          DY1=YD(IPI)-Y0
          DZ1=ZD(IPI)-Z0
          IC2MN=IC1+1
          DO 22  IC2=IC2MN,NCP0
            JIPC=JIPC0+IC2
            IPI=IPC(JIPC)
            DX2=XD(IPI)-X0
            DY2=YD(IPI)-Y0
            DNMZ=DX1*DY2-DY1*DX2
            IF(DNMZ.EQ.0.0)    GO TO 22
            DZ2=ZD(IPI)-Z0
            DNMX=DY1*DZ2-DZ1*DY2
            DNMY=DZ1*DX2-DX1*DZ2
            IF(DNMZ.GE.0.0)    GO TO 21
            DNMX=-DNMX
            DNMY=-DNMY
            DNMZ=-DNMZ
   21       NMX=NMX+DNMX
            NMY=NMY+DNMY
            NMZ=NMZ+DNMZ
   22     CONTINUE
   23   CONTINUE
        JPD0=5*IP0
        PD(JPD0-4)=-NMX/NMZ
        PD(JPD0-3)=-NMY/NMZ
   24 CONTINUE
C ESTIMATION OF ZXX, ZXY, AND ZYY
   30 DO 34  IP0=1,NDP0
```

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PRECIPITATION VARIABILITY IN THE U. S. A. FOR MICROWAVE TERREST--ETC(U)
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UNCLASSIFIED OT-77-134 NL

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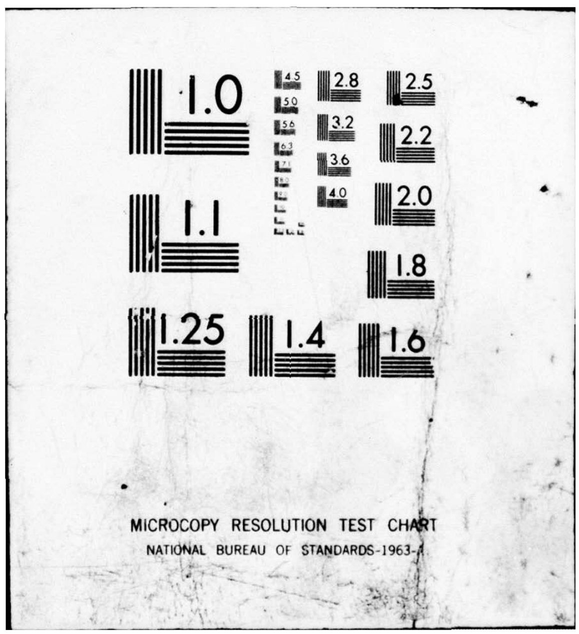
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5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
      JPD0=JPD0+5
      X0=XD(IP0)
      JPD0=5*IP0
      Y0=YD(IP0)
      ZX0=PD(JPD0-4)
      ZY0=PD(JPD0-3)
      NMXX=0.0
      NMXY=0.0
      NMYX=0.0
      NMYY=0.0
      NMZ =0.0
      JIPC0=NCP0*(IP0-1)
      DO 33  IC1=1,NCPM1
        JIPC=JIPC0+IC1
        IPI=IPC(JIPC)
        DX1=XD(IPI)-X0
        DY1=YD(IPI)-Y0
        JPD=5*IPI
        DZX1=PD(JPD-4)-ZX0
        DZY1=PD(JPD-3)-ZY0
        IC2MN=IC1+1
        DO 32  IC2=IC2MN,NCP0
          JIPC=JIPC0+IC2
          IPI=IPC(JIPC)
          DX2=XD(IPI)-X0
          DY2=YD(IPI)-Y0
          DNMZ =DX1*DY2 -DY1*DX2
          IF(DNMZ.EQ.0.0)     GO TO 32
          JPD=5*IPI
          DZX2=PD(JPD-4)-ZX0
          DZY2=PD(JPD-3)-ZY0
          DNMXX=DY1*DZX2-DZX1*DY2
          DNMXY=DZX1*DX2-DX1*DZX2
          DNMYX=DY1*DZY2-DZY1*DY2
          DNMYY=DZY1*DX2-DX1*DZY2
          IF(DNMZ.GE.0.0)     GO TO 31
          DNMXX=-DNMXX
          DNMXY=-DNMXY
          DNMYX=-DNMYX
          DNMYY=-DNMYY
          DNMZ =-DNMZ
   31     NMXX=NMXX+DNMXX
          NMXY=NMXY+DNMXY
          NMYX=NMYX+DNMYX
          NMYY=NMYY+DNMYY
          NMZ =NMZ +DNMZ
   32   CONTINUE
   33 CONTINUE
      PD(JPD0-2)=-NMXX/NMZ
      PD(JPD0-1)=-(NMXY+NMYX)/(2.0*NMZ)
      PD(JPD0)   =-NMYY/NMZ
   34 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE  IDPTIP(XD,YD,ZD,NT,IPT,NL,IPL,PDD,ITI,XII,YII,
     1                   ZII)
C THIS SUBROUTINE PERFORMS PUNCTUAL INTERPOLATION OR EXTRAPOLA-
C TION, I.E., DETERMINES THE Z VALUE AT A POINT.
C THE INPUT PARAMETERS ARE
C     XD,YD,ZD = ARRAYS OF DIMENSION NDP CONTAINING THE X,
C           Y, AND Z COORDINATES OF THE DATA POINTS, WHERE
C           NDP IS THE NUMBER OF THE DATA POINTS,
C     NT  = NUMBER OF TRIANGLES,
C     IPT = INTEGER ARRAY OF DIMENSION 3*NT CONTAINING THE
C           POINT NUMBERS OF THE VERTEXES OF THE TRIANGLES,
C     NL  = NUMBER OF BORDER LINE SEGMENTS,
C     IPL = INTEGER ARRAY OF DIMENSION 3*NL CONTAINING THE
C           POINT NUMBERS OF THE END POINTS OF THE BORDER
C           LINE SEGMENTS AND THEIR RESPECTIVE TRIANGLE
C           NUMBERS,
C     PDD = ARRAY OF DIMENSION 5*NDP CONTAINING THE PARTIAL
C           DERIVATIVES AT THE DATA POINTS,
C     ITI = TRIANGLE NUMBER OF THE TRIANGLE IN WHICH LIES
C           THE POINT FOR WHICH INTERPOLATION IS TO BE
C           PERFORMED,
C     XII,YII = X AND Y COORDINATES OF THE POINT FOR WHICH
C           INTERPOLATION IS TO BE PERFORMED.
C THE OUTPUT PARAMETER IS
C     ZII = INTERPOLATED Z VALUE.
C DECLARATION STATEMENTS
      DIMENSION XD(50),YD(50),ZD(50),IPT(285),IPL(300),PDD(250)
      COMMON/IDPI/ITPV
      DIMENSION   X(3),Y(3),Z(3),PD(15),
     1            ZU(3),ZV(3),ZUU(3),ZUV(3),ZVV(3)
      REAL        LU,LV
      EQUIVALENCE (P5,P50)
C PRELIMINARY PROCESSING
   10 ITO=ITI
      NTL=NT+NL
      IF(ITO.LE.NTL)        GO TO 20
      IL1=ITO/NTL
      IL2=ITO-IL1*NTL
      IF(IL1.EQ.IL2)        GO TO 40
      GO TO 60
C CALCULATION OF ZII BY INTERPOLATION.
C CHECKS IF THE NECESSARY COEFFICIENTS HAVE BEEN CALCULATED.
   20 IF(ITO.EQ.ITPV)       GO TO 30
C LOADS COORDINATE AND PARTIAL DERIVATIVE VALUES AT THE
C VERTEXES.
   21 JIPT=3*(ITO-1)
      JPD=0
      DO 23  I=1,3
        JIPT=JIPT+1
        IDP=IPT(JIPT)
        X(I)=XD(IDP)
        Y(I)=YD(IDP)
        Z(I)=ZD(IDP)
        JPDD=5*(IDP-1)
        DO 22  KPD=1,5
          JPD=JPD+1
          JPDD=JPDD+1
          PD(JPD)=PDD(JPDD)
   22   CONTINUE
   23 CONTINUE
C DETERMINES THE COEFFICIENTS FOR THE COORDINATE SYSTEM
C TRANSFORMATION FROM THE X-Y SYSTEM TO THE U-V SYSTEM
C AND VICE VERSA.
   24 X0=X(1)
```

```
      Y0=Y(1)
      A=X(2)-X0
      B=X(3)-X0
      C=Y(2)-Y0
      D=Y(3)-Y0
      AD=A*D
      BC=B*C
      DLT=AD-BC
      AP= D/DLT
      BP=-B/DLT
      CP=-C/DLT
      DP= A/DLT
C CONVERTS THE PARTIAL DERIVATIVES AT THE VERTEXES OF THE
C TRIANGLE FOR THE U-V COORDINATE SYSTEM.
   25 AA=A*A
      ACT2=2.0*A*C
      CC=C*C
      AB=A*B
      ADBC=AD+BC
      CD=C*D
      BB=B*B
      BDT2=2.0*B*D
      DD=D*D
      DO 26  I=1,3
        JPD=5*I
        ZU(I)=A*PD(JPD-4)+C*PD(JPD-3)
        ZV(I)=B*PD(JPD-4)+D*PD(JPD-3)
        ZUU(I)=AA*PD(JPD-2)+ACT2*PD(JPD-1)+CC*PD(JPD)
        ZUV(I)=AB*PD(JPD-2)+ADBC*PD(JPD-1)+CD*PD(JPD)
        ZVV(I)=BB*PD(JPD-2)+BDT2*PD(JPD-1)+DD*PD(JPD)
   26 CONTINUE
C CALCULATES THE COEFFICIENTS OF THE POLYNOMIAL.
   27 P00=Z(1)
      P10=ZU(1)
      P01=ZV(1)
      P20=0.5*ZUU(1)
      P11=ZUV(1)
      P02=0.5*ZVV(1)
      H1=Z(2)-P00-P10-P20
      H2=ZU(2)-P10-ZUU(1)
      H3=ZUU(2)-ZUU(1)
      P30= 10.0*H1-4.0*H2+0.5*H3
      P40=-15.0*H1+7.0*H2     -H3
      P50=  6.0*H1-3.0*H2+0.5*H3
      H1=Z(3)-P00-P01-P02
      H2=ZV(3)-P01-ZVV(1)
      H3=ZVV(3)-ZVV(1)
      P03= 10.0*H1-4.0*H2+0.5*H3
      P04=-15.0*H1+7.0*H2     -H3
      P05=  6.0*H1-3.0*H2+0.5*H3
      LU=SQRT(AA+CC)
      LV=SQRT(BB+DD)
      THXU=ATAN2(C,A)
      THUV=ATAN2(D,B)-THXU
      CSUV=COS(THUV)
      P41=5.0*LV*CSUV/LU*P50
      P14=5.0*LU*CSUV/LV*P05
      H1=ZV(2)-P01-P11-P41
      H2=ZUV(2)-P11-4.0*P41
      P21= 3.0*H1-H2
      P31=-2.0*H1+H2
      H1=ZU(3)-P10-P11-P14
      H2=ZUV(3)-P11-4.0*P14
      P12= 3.0*H1-H2
```

```
      P13=-2.0*H1+H2
      THUS=ATAN2(D-C,B-A)-THXU
      THSV=THUV-THUS
      AA= SIN(THSV)/LU
      BB=-COS(THSV)/LU
      CC= SIN(THUS)/LV
      DD= COS(THUS)/LV
      AC=AA*CC
      AD=AA*DD
      BC=BB*CC
      G1=AA*AC*(3.0*BC+2.0*AD)
      G2=CC*AC*(3.0*AD+2.0*BC)
      H1=-AA*AA*AA*(5.0*AA*BB*P50+(4.0*BC+AD)*P41)
     1   -CC*CC*CC*(5.0*CC*DD*P05+(4.0*AD+BC)*P14)
      H2=0.5*ZVV(2)-P02-P12
      H3=0.5*ZUU(3)-P20-P21
      P22=(G1*H2+G2*H3-H1)/(G1+G2)
      P32=H2-P22
      P23=H3-P22
      ITPV=ITO
C CONVERTS XII AND YII TO U-V SYSTEM.
   30 DX=XII-X0
      DY=YII-Y0
      U=AP*DX+BP*DY
      V=CP*DX+DP*DY
C EVALUATES THE POLYNOMIAL.
   31 P0=P00+V*(P01+V*(P02+V*(P03+V*(P04+V*P05))))
      P1=P10+V*(P11+V*(P12+V*(P13+V*P14)))
      P2=P20+V*(P21+V*(P22+V*P23))
      P3=P30+V*(P31+V*P32)
      P4=P40+V*P41
      ZII=P0+U*(P1+U*(P2+U*(P3+U*(P4+U*P5))))
      RETURN
C CALCULATION OF ZII BY EXTRAPOLATION IN THE RECTANGLE.
C CHECKS IF THE NECESSARY COEFFICIENTS HAVE BEEN CALCULATED.
   40 IF(ITO.EQ.ITPV)      GO TO 50
C LOADS COORDINATE AND PARTIAL DERIVATIVE VALUES AT THE END
C POINTS OF THE BORDER LINE SEGMENT.
   41 JIPL=3*(IL1-1)
      JPD=0
      DO 43  I=1,2
        JIPL=JIPL+1
        IDP=IPL(JIPL)
        X(I)=XD(IDP)
        Y(I)=YD(IDP)
        Z(I)=ZD(IDP)
        JPDD=5*(IDP-1)
        DO 42  KPD=1,5
          JPD=JPD+1
          JPDD=JPDD+1
          PD(JPD)=PDD(JPDD)
   42   CONTINUE
   43 CONTINUE
C DETERMINES THE COEFFICIENTS FOR THE COORDINATE SYSTEM
C TRANSFORMATION FROM THE X-Y SYSTEM TO THE U-V SYSTEM
C AND VICE VERSA.
   44 X0=X(1)
      Y0=Y(1)
      A=Y(2)-Y(1)
      B=X(2)-X(1)
      C=-B
      D=A
      AD=A*D
      BC=B*C
```

```
      DLT=AD-BC
      AP= D/DLT
      BP=-B/DLT
      CP=-BP
      DP= AP
C CONVERTS THE PARTIAL DERIVATIVES AT THE END POINTS OF THE
C BORDER LINE SEGMENT FOR THE U-V COORDINATE SYSTEM.
   45 AA=A*A
      ACT2=2.0*A*C
      CC=C*C
      AB=A*B
      ADBC=AD+BC
      CD=C*D
      BB=B*B
      BDT2=2.0*B*D
      DD=D*D
      DO 46  I=1,2
        JPD=5*I
        ZU(I)=A*PD(JPD-4)+C*PD(JPD-3)
        ZV(I)=B*PD(JPD-4)+D*PD(JPD-3)
        ZUU(I)=AA*PD(JPD-2)+ACT2*PD(JPD-1)+CC*PD(JPD)
        ZUV(I)=AB*PD(JPD-2)+ADBC*PD(JPD-1)+CD*PD(JPD)
        ZVV(I)=BB*PD(JPD-2)+BDT2*PD(JPD-1)+DD*PD(JPD)
   46 CONTINUE
C CALCULATES THE COEFFICIENTS OF THE POLYNOMIAL.
   47 P00=Z(1)
      P10=ZU(1)
      P01=ZV(1)
      P20=0.5*ZUU(1)
      P11=ZUV(1)
      P02=0.5*ZVV(1)
      H1=Z(2)-P00-P01-P02
      H2=ZV(2)-P01-ZVV(1)
      H3=ZVV(2)-ZVV(1)
      P03= 10.0*H1-4.0*H2+0.5*H3
      P04=-15.0*H1+7.0*H2    -H3
      P05=  6.0*H1-3.0*H2+0.5*H3
      H1=ZU(2)-P10-P11
      H2=ZUV(2)-P11
      P12= 3.0*H1-H2
      P13=-2.0*H1+H2
      P21=0.0
      P23=-ZUU(2)+ZUU(1)
      P22=-1.5*P23
      ITPV=IT0
C CONVERTS XII AND YII TO U-V SYSTEM.
   50 DX=XII-X0
      DY=YII-Y0
      U=AP*DX+BP*DY
      V=CP*DX+DP*DY
C EVALUATES THE POLYNOMIAL.
   51 P0=P00+V*(P01+V*(P02+V*(P03+V*(P04+V*P05))))
      P1=P10+V*(P11+V*(P12+V*P13))
      P2=P20+V*(P21+V*(P22+V*P23))
      ZII=P0+U*(P1+U*P2)
      RETURN
C CALCULATION OF ZII BY EXTRAPOLATION IN THE TRIANGLE.
C CHECKS IF THE NECESSARY COEFFICIENTS HAVE BEEN CALCULATED.
   60 IF(IT0.EQ.ITPV)      GO TO 70
C LOADS COORDINATE AND PARTIAL DERIVATIVE VALUES AT THE VERTEX
C OF THE TRIANGLE.
   61 JIPL=3*IL2-2
      IDP=IPL(JIPL)
      X(1)=XD(IDP)
```

```
      Y(1)=Y0(IDP)
      Z(1)=Z0(IDP)
      JPDD=5*(IDP-1)
      DO 62  KPD=1,5
        JPDD=JPDD+1
        PD(KPD)=PDD(JPDD)
   62 CONTINUE
C CALCULATES THE COEFFICIENTS OF THE POLYNOMIAL.
   67 P00=Z(1)
      P10=PD(1)
      P01=PD(2)
      P20=0.5*PD(3)
      P11=PD(4)
      P02=0.5*PD(5)
      ITPV=IT0
C CONVERTS XII AND YII TO U-V SYSTEM.
   70 U=XII-X(1)
      V=YII-Y(1)
C EVALUATES THE POLYNOMIAL.
   71 P0=P00+V*(P01+V*P02)
      P1=P10+V*P11
      ZII=P0+U*(P1+U*P20)
      RETURN
      END
```

```
      SUBROUTINE  IDTANG(NDP,XD,YD,NT,IPT,NL,IPL,IWL,IWP,WK)
C THIS SUBROUTINE PERFORMS TRIANGULATION.  IT DIVIDES THE X-Y
C PLANE INTO A NUMBER OF TRIANGLES ACCORDING TO GIVEN DATA
C POINTS IN THE PLANE, DETERMINES LINE SEGMENTS THAT FORM THE
C BORDER OF DATA AREA, AND DETERMINES THE TRIANGLE NUMBERS
C CORRESPONDING TO THE BORDER LINE SEGMENTS.
C AT COMPLETION, POINT NUMBERS OF THE VERTEXES OF EACH TRIANGLE
C ARE LISTED COUNTER-CLOCKWISE.  POINT NUMBERS OF THE END POINTS
C OF EACH BORDER LINE SEGMENT ARE LISTED COUNTER-CLOCKWISE,
C LISTING ORDER OF THE LINE SEGMENTS BEING COUNTER-CLOCKWISE.
C THE LUN CONSTANT IN THE DATA INITIALIZATION STATEMENT IS THE
C LOGICAL UNIT NUMBER OF THE STANDARD OUTPUT UNIT AND IS,
C THEREFORE, SYSTEM DEPENDENT.
C THIS SUBROUTINE CALLS THE IDXCHG FUNCTION.
C THE INPUT PARAMETERS ARE
C     NDP = NUMBER OF DATA POINTS,
C     XD  = ARRAY OF DIMENSION NDP CONTAINING THE
C           X COORDINATES OF THE DATA POINTS,
C     YD  = ARRAY OF DIMENSION NDP CONTAINING THE
C           Y COORDINATES OF THE DATA POINTS.
C THE OUTPUT PARAMETERS ARE
C     NT  = NUMBER OF TRIANGLES,
C     IPT = INTEGER ARRAY OF DIMENSION 6*NDP-15, WHERE THE
C           POINT NUMBERS OF THE VERTEXES OF THE (IT)TH
C           TRIANGLE ARE TO BE STORED AS THE (3*IT-2)ND,
C           (3*IT-1)ST, AND (3*IT)TH ELEMENTS,
C           IT=1,2,...,NT,
C     NL  = NUMBER OF BORDER LINE SEGMENTS,
C     IPL = INTEGER ARRAY OF DIMENSION 6*NDP, WHERE THE
C           POINT NUMBERS OF THE END POINTS OF THE (IL)TH
C           BORDER LINE SEGMENT AND ITS RESPECTIVE TRIANGLE
C           NUMBER ARE TO BE STORED AS THE (3*IL-2)ND,
C           (3*IL-1)ST, AND (3*IL)TH ELEMENTS,
C           IL=1,2,..., NL.
C THE OTHER PARAMETERS ARE
C     IWL = INTEGER ARRAY OF DIMENSION 18*NDP USED
C           INTERNALLY AS A WORK AREA,
C     IWP = INTEGER ARRAY OF DIMENSION NDP USED
C           INTERNALLY AS A WORK AREA,
C     WK  = ARRAY OF DIMENSION NDP USED INTERNALLY AS A
C           WORK AREA.
C DECLARATION STATEMENTS
      DIMENSION XD(50),YD(50),IPT(285),IPL(300),IWL(900),IWP(50),WK(50)
      DIMENSION   ITF(2)
      DATA  RATIO/1.0E-6/, NREP/100/, LUN/6/
C STATEMENT FUNCTIONS
      DSQF(U1,V1,U2,V2)=(U2-U1)**2+(V2-V1)**2
      SIDE(U1,V1,U2,V2,U3,V3)=(V3-V1)*(U2-U1)-(U3-U1)*(V2-V1)
C PRELIMINARY PROCESSING
   10 NDP0=NDP
      NDPM1=NDP0-1
      IF(NDP0.LT.4)        GO TO 90
C DETERMINES THE CLOSEST PAIR OF DATA POINTS AND THEIR MIDPOINT.
   20 DSQMN=DSQF(XD(1),YD(1),XD(2),YD(2))
      IPMN1=1
      IPMN2=2
      DO 22  IP1=1,NDPM1
        X1=XD(IP1)
        Y1=YD(IP1)
        IP1P1=IP1+1
        DO 21  IP2=IP1P1,NDP0
          DSQI=DSQF(X1,Y1,XD(IP2),YD(IP2))
          IF(DSQI.EQ.0.0)       GO TO 91
          IF(DSQI.GE.DSQMN)     GO TO 21
```

```
      DSQMN=DSQI
      IPMN1=IP1
      IPMN2=IP2
   21   CONTINUE
   22 CONTINUE
      DSQ12=DSQMN
      XDMP=(XD(IPMN1)+XD(IPMN2))/2.0
      YDMP=(YD(IPMN1)+YD(IPMN2))/2.0
C SORTS THE OTHER (NDP-2) DATA POINTS IN ASCENDING ORDER OF
C DISTANCE FROM THE MIDPOINT AND STORES THE SORTED DATA POINT
C NUMBERS IN THE IWP ARRAY.
   30 JP1=2
      DO 31  IP1=1,NDP0
        IF(IP1.EQ.IPMN1.OR.IP1.EQ.IPMN2)      GO TO 31
        JP1=JP1+1
        IWP(JP1)=IP1
        WK(JP1)=DSQF(XDMP,YDMP,XD(IP1),YD(IP1))
   31 CONTINUE
      DO 33  JP1=3,NDPM1
        DSQMN=WK(JP1)
        JPMN=JP1
        DO 32  JP2=JP1,NDP0
          IF(WK(JP2).GE.DSQMN)       GO TO 32
          DSQMN=WK(JP2)
          JPMN=JP2
   32   CONTINUE
        ITS=IWP(JP1)
        IWP(JP1)=IWP(JPMN)
        IWP(JPMN)=ITS
        WK(JPMN)=WK(JP1)
   33 CONTINUE
C IF NECESSARY, MODIFIES THE ORDERING IN SUCH A WAY THAT THE
C FIRST THREE DATA POINTS ARE NOT COLLINEAR.
   35 AR=DSQ12*RATIO
      X1=XD(IPMN1)
      Y1=YD(IPMN1)
      DX21=XD(IPMN2)-X1
      DY21=YD(IPMN2)-Y1
      DO 36  JP=3,NDP0
        IP=IWP(JP)
        IF(ABS((YD(IP)-Y1)*DX21-(XD(IP)-X1)*DY21).GT.AR)
     1               GO TO 37
   36 CONTINUE
      GO TO 92
   37 IF(JP.EQ.3)     GO TO 40
      JPMX=JP
      JP=JPMX+1
      DO 38  JPC=4,JPMX
        JP=JP-1
        IWP(JP)=IWP(JP-1)
   38 CONTINUE
      IWP(3)=IP
C FORMS THE FIRST TRIANGLE.  STORES POINT NUMBERS OF THE VER-
C TEXES OF THE TRIANGLE IN THE IPT ARRAY, AND STORES POINT NUM-
C BERS OF THE BORDER LINE SEGMENTS AND THE TRIANGLE NUMBER IN
C THE IPL ARRAY.
   40 IP1=IPMN1
      IP2=IPMN2
      IP3=IWP(3)
      IF(SIDE(XD(IP1),YD(IP1),XD(IP2),YD(IP2),XD(IP3),YD(IP3))
     1     .GE.0.0)        GO TO 41
      IP1=IPMN2
      IP2=IPMN1
   41 NT0=1
```

```
      NTT3=3
      IPT(1)=IP1
      IPT(2)=IP2
      IPT(3)=IP3
      NLC=3
      NLT3=9
      IPL(1)=IP1
      IPL(2)=IP2
      IPL(3)=1
      IPL(4)=IP2
      IPL(5)=IP3
      IPL(6)=1
      IPL(7)=IP3
      IPL(8)=IP1
      IPL(9)=1
C ADDS THE REMAINING (NDP-3) DATA POINTS, ONE BY ONE.
   50 DO 79  JP1=4,NDP0
        IP1=IWP(JP1)
        X1=XD(IP1)
        Y1=YD(IP1)
C - DETERMINES THE VISIBLE BORDER LINE SEGMENTS.
        IP2=IPL(1)
        JPMN=1
        DXMN=XD(IP2)-X1
        DYMN=YD(IP2)-Y1
        DSQMN=DXMN**2+DYMN**2
        ARMN=DSQMN*RATIO
        JPMX=1
        DXMX=DXMN
        DYMX=DYMN
        DSQMX=DSQMN
        ARMX=ARMN
        DO 52  JP2=2,NL0
          IP2=IPL(3*JP2-2)
          DX=XD(IP2)-X1
          DY=YD(IP2)-Y1
          AR=DY*DXMN-DX*DYMN
          IF(AR.GT.ARMN)        GO TO 51
          DSQI=DX**2+DY**2
          IF(AR.GE.(-ARMN).AND.DSQI.GE.DSQMN)        GO TO 51
          JPMN=JP2
          DXMN=DX
          DYMN=DY
          DSQMN=DSQI
          ARMN=DSQMN*RATIO
   51     AR=DY*DXMX-DX*DYMX
          IF(AR.LT.(-ARMX))     GO TO 52
          DSQI=DX**2+DY**2
          IF(AR.LE.ARMX.AND.DSQI.GE.DSQMX)    GO TO 52
          JPMX=JP2
          DXMX=DX
          DYMX=DY
          DSQMX=DSQI
          ARMX=DSQMX*RATIO
   52   CONTINUE
        IF(JPMX.LT.JPMN)  JPMX=JPMX+NL0
        NSH=JPMN-1
        IF(NSH.LE.0)        GO TO 60
C - SHIFTS (ROTATES) THE IPL ARRAY TO HAVE THE INVISIBLE BORDER
C - LINE SEGMENTS CONTAINED IN THE FIRST PART OF THE IPL ARRAY.
        NSHT3=NSH*3
        DO 53  JP2T3=3,NSHT3,3
          JP3T3=JP2T3+NLT3
          IPL(JP3T3-2)=IPL(JP2T3-2)
```

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         IPL(JP3T3-1)=IPL(JP2T3-1)
         IPL(JP3T3)   =IPL(JP2T3)
   53   CONTINUE
        DO 54  JP2T3=3,NLT3,3
         JP3T3=JP2T3+NSHT3
         IPL(JP2T3-2)=IPL(JP3T3-2)
         IPL(JP2T3-1)=IPL(JP3T3-1)
         IPL(JP2T3)   =IPL(JP3T3)
   54   CONTINUE
        JPMX=JPMX-NSH
C - ADDS TRIANGLES TO THE IPT ARRAY, UPDATES BORDER LINE
C - SEGMENTS IN THE IPL ARRAY, AND SETS FLAGS FOR THE BORDER
C - LINE SEGMENTS TO BE REEXAMINED IN THE IWL ARRAY.
   60   JWL=0
        DO 64  JP2=JPMX,NL0
         JP2T3=JP2*3
         IPL1=IPL(JP2T3-2)
         IPL2=IPL(JP2T3-1)
         IT   =IPL(JP2T3)
C - - ADDS A TRIANGLE TO THE IPT ARRAY.
         NT0=NT0+1
         NTT3=NTT3+3
         IPT(NTT3-2)=IPL2
         IPT(NTT3-1)=IPL1
         IPT(NTT3)   =IP1
C - - UPDATES BORDER LINE SEGMENTS IN THE IPL ARRAY.
         IF(JP2.NE.JPMX)        GO TO 61
         IPL(JP2T3-1)=IP1
         IPL(JP2T3)   =NT0
   61    IF(JP2.NE.NL0)         GO TO 62
         NLN=JPMX+1
         NLNT3=NLN*3
         IPL(NLNT3-2)=IP1
         IPL(NLNT3-1)=IPL(1)
         IPL(NLNT3)   =NT0
C - - DETERMINES THE VERTEX THAT DOES NOT LIE ON THE BORDER
C - - LINE SEGMENTS.
   62    ITT3=IT*3
         IPTI=IPT(ITT3-2)
         IF(IPTI.NE.IPL1.AND.IPTI.NE.IPL2)   GO TO 63
         IPTI=IPT(ITT3-1)
         IF(IPTI.NE.IPL1.AND.IPTI.NE.IPL2)   GO TO 63
         IPTI=IPT(ITT3)
C - - CHECKS IF THE EXCHANGE IS NECESSARY.
   63    IF(IDXCHG(XD,YD,IP1,IPTI,IPL1,IPL2).EQ.0)       GO TO 64
C - - MODIFIES THE IPT ARRAY WHEN NECESSARY.
         IPT(ITT3-2)=IPTI
         IPT(ITT3-1)=IPL1
         IPT(ITT3)   =IP1
         IPT(NTT3-1)=IPTI
         IF(JP2.EQ.JPMX)        IPL(JP2T3)=IT
         IF(JP2.EQ.NL0.AND.IPL(3).EQ.IT)      IPL(3)=NT0
C - - SETS FLAGS IN THE IWL ARRAY.
         JWL=JWL+4
         IWL(JWL-3)=IPL1
         IWL(JWL-2)=IPTI
         IWL(JWL-1)=IPTI
         IWL(JWL)   =IPL2
   64   CONTINUE
        NL0=NLN
        NLT3=NLNT3
        NLF=JWL/2
        IF(NLF.EQ.0)        GO TO 79
C - IMPROVES TRIANGULATION.
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70    NTT3P3=NTT3+3
      DO 78  IREP=1,NREP
        DO 76  ILF=1,NLF
          ILFT2=ILF*2
          IPL1=IWL(ILFT2-1)
          IPL2=IWL(ILFT2)
C - - LOCATES IN THE IPT ARRAY TWO TRIANGLES ON BOTH SIDES OF
C - - THE FLAGGED LINE SEGMENT.
          NTF=0
          DO 71  ITT3R=3,NTT3,3
            ITT3=NTT3P3-ITT3R
            IPT1=IPT(ITT3-2)
            IPT2=IPT(ITT3-1)
            IPT3=IPT(ITT3)
            IF(IPL1.NE.IPT1.AND.IPL1.NE.IPT2.AND.
     1         IPL1.NE.IPT3)       GO TO 71
            IF(IPL2.NE.IPT1.AND.IPL2.NE.IPT2.AND.
     1         IPL2.NE.IPT3)       GO TO 71
            NTF=NTF+1
            ITF(NTF)=ITT3/3
            IF(NTF.EQ.2)      GO TO 72
   71     CONTINUE
          IF(NTF.LT.2)        GO TO 76
C - - DETERMINES THE VERTEXES OF THE TRIANGLES THAT DO NOT LIE
C - - ON THE LINE SEGMENT.
   72     IT1T3=ITF(1)*3
          IPTI1=IPT(IT1T3-2)
          IF(IPTI1.NE.IPL1.AND.IPTI1.NE.IPL2)     GO TO 73
          IPTI1=IPT(IT1T3-1)
          IF(IPTI1.NE.IPL1.AND.IPTI1.NE.IPL2)     GO TO 73
          IPTI1=IPT(IT1T3)
   73     IT2T3=ITF(2)*3
          IPTI2=IPT(IT2T3-2)
          IF(IPTI2.NE.IPL1.AND.IPTI2.NE.IPL2)     GO TO 74
          IPTI2=IPT(IT2T3-1)
          IF(IPTI2.NE.IPL1.AND.IPTI2.NE.IPL2)     GO TO 74
          IPTI2=IPT(IT2T3)
C - - CHECKS IF THE EXCHANGE IS NECESSARY.
   74     IF(IDXCHG(XD,YD,IPTI1,IPTI2,IPL1,IPL2).EQ.0)
     1      GO TO 76
C - - MODIFIES THE IPT ARRAY WHEN NECESSARY.
          IPT(IT1T3-2)=IPTI1
          IPT(IT1T3-1)=IPTI2
          IPT(IT1T3)  =IPL1
          IPT(IT2T3-2)=IPTI2
          IPT(IT2T3-1)=IPTI1
          IPT(IT2T3)  =IPL2
C - - SETS NEW FLAGS.
          JWL=JWL+8
          IWL(JWL-7)=IPL1
          IWL(JWL-6)=IPTI1
          IWL(JWL-5)=IPTI1
          IWL(JWL-4)=IPL2
          IWL(JWL-3)=IPL2
          IWL(JWL-2)=IPTI2
          IWL(JWL-1)=IPTI2
          IWL(JWL)  =IPL1
          DO 75  JLT3=3,NLT3,3
            IPLJ1=IPL(JLT3-2)
            IPLJ2=IPL(JLT3-1)
            IF((IPLJ1.EQ.IPL1.AND.IPLJ2.EQ.IPTI2).OR.
     1         (IPLJ2.EQ.IPL1.AND.IPLJ1.EQ.IPTI2))
     2                        IPL(JLT3)=ITF(1)
            IF((IPLJ1.EQ.IPL2.AND.IPLJ2.EQ.IPTI1).OR.
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```
     1              (IPLJ2.EQ.IPL2.AND.IPLJ1.EQ.IPTI1))
     2                                 IPL(JLT3)=ITF(2)
   75         CONTINUE
   76       CONTINUE
            NLFC=NLF
            NLF=JWL/2
            IF(NLF.EQ.NLFC)         GO TO 79
C - - RESETS THE IWL ARRAY FOR THE NEXT ROUND.
            JWL=0
            JWL1MN=(NLFC+1)*2
            NLFT2=NLF*2
            DO 77   JWL1=JWL1MN,NLFT2,2
              JWL=JWL+2
              IWL(JWL-1)=IWL(JWL1-1)
              IWL(JWL)   =IWL(JWL1)
   77       CONTINUE
            NLF=JWL/2
   78     CONTINUE
   79 CONTINUE
C REARRANGES THE IPT ARRAY SO THAT THE VERTEXES OF EACH TRIANGLE
C ARE LISTED COUNTER-CLOCKWISE.
   80 DO 81   ITT3=3,NTT3,3
          IP1=IPT(ITT3-2)
          IP2=IPT(ITT3-1)
          IP3=IPT(ITT3)
          IF(SIDE(XD(IP1),YD(IP1),XD(IP2),YD(IP2),XD(IP3),YD(IP3))
     1         .GE.0.0)       GO TO 81
          IPT(ITT3-2)=IP2
          IPT(ITT3-1)=IP1
   81 CONTINUE
      NT=NT0
      NL=NL0
      RETURN
C ERROR EXIT
   90 WRITE (LUN,2090)   NDP0
      GO TO 93
   91 WRITE (LUN,2091)   NDP0,IP1,IP2,X1,Y1
      GO TO 93
   92 WRITE (LUN,2092)   NDP0
   93 WRITE (LUN,2093)
      NT=0
      RETURN
C FORMAT STATEMENTS
 2090 FORMAT(1X/23H ***    NDP LESS THAN 4./8H   NDP =,I5)
 2091 FORMAT(1X/29H ***    IDENTICAL DATA POINTS./
     1    8H    NDP =,I5,5X,5HIP1 =,I5,5X,5HIP2 =,I5,
     2    5X,4HXD =,E12.4,5X,4HYD =,E12.4)
 2092 FORMAT(1X/33H ***    ALL COLLINEAR DATA POINTS./
     1    8H    NDP =,I5)
 2093 FORMAT(35H ERROR DETECTED IN ROUTINE   IDTANG/)
      END
```

```
      FUNCTION  IDXCHG(X,Y,I1,I2,I3,I4)
C THIS FUNCTION DETERMINES WHETHER OR NOT THE EXCHANGE OF TWO
C TRIANGLES IS NECESSARY ON THE BASIS OF MAX-MIN-ANGLE CRITERION
C BY C. L. LAWSON.
C THE INPUT PARAMETERS ARE
C     X,Y = ARRAYS CONTAINING THE COORDINATES OF THE DATA
C           POINTS,
C     I1,I2,I3,I4 = POINT NUMBERS OF FOUR POINTS P1, P2,
C           P3, AND P4 THAT FORM A QUADRILATERAL WITH P3
C           AND P4 CONNECTED DIAGONALLY.
C THIS FUNCTION RETURNS AN INTEGER VALUE 1 (ONE) WHEN AN EX-
C CHANGE IS NECESSARY, AND 0 (ZERO) OTHERWISE.
C DECLARATION STATEMENTS
      DIMENSION   X(100),Y(100)
      EQUIVALENCE (C2SQ,C1SQ),(A3SQ,B2SQ),(B3SQ,A1SQ),
     1            (A4SQ,B1SQ),(B4SQ,A2SQ),(C4SQ,C3SQ)
C PRELIMINARY PROCESSING
   10 X1=X(I1)
      Y1=Y(I1)
      X2=X(I2)
      Y2=Y(I2)
      X3=X(I3)
      Y3=Y(I3)
      X4=X(I4)
      Y4=Y(I4)
C CALCULATION
   20 IDX=0
      U3=(Y2-Y3)*(X1-X3)-(X2-X3)*(Y1-Y3)
      U4=(Y1-Y4)*(X2-X4)-(X1-X4)*(Y2-Y4)
      IF(U3*U4.LE.0.0)    GO TO 30
      U1=(Y3-Y1)*(X4-X1)-(X3-X1)*(Y4-Y1)
      U2=(Y4-Y2)*(X3-X2)-(X4-X2)*(Y3-Y2)
      A1SQ=(X1-X3)**2+(Y1-Y3)**2
      B1SQ=(X4-X1)**2+(Y4-Y1)**2
      C1SQ=(X3-X4)**2+(Y3-Y4)**2
      A2SQ=(X2-X4)**2+(Y2-Y4)**2
      B2SQ=(X3-X2)**2+(Y3-Y2)**2
      C3SQ=(X2-X1)**2+(Y2-Y1)**2
      S1SQ=U1*U1/(C1SQ*AMAX1(A1SQ,B1SQ))
      S2SQ=U2*U2/(C2SQ*AMAX1(A2SQ,B2SQ))
      S3SQ=U3*U3/(C3SQ*AMAX1(A3SQ,B3SQ))
      S4SQ=U4*U4/(C4SQ*AMAX1(A4SQ,B4SQ))
      IF(AMIN1(S1SQ,S2SQ).LT.AMIN1(S3SQ,S4SQ))      IDX=1
   30 IDXCHG=IDX
      RETURN
      END
```

```
      BLOCK DATA RMSVAR

      COMMON/STATS/ VAREM(19),VARD(19),VARU(19)
      COMMON/RMSERR/ RMSM(19), RMSD(19), RMSU(19)
C
C     THIS BLOCK DATA ROUTINE INITIALIZES ARRAYS THAT ARE USED IN VARNCE
C        ANY ARRAY STARTING WITH VAR CONTAINS THE SPATIAL,TEMPORAL
C        VARIANCE WHILE ANY ARRAY STARTING WITH RMS CONTAINS THE RMS
C        ERROR DUE TO APPROXIMATION.
C
      DATA((VAREM(I),I=1,19)= 105267.8, 78316.02, 45394.56, 46173.41,
     A98721.64, 28264.33, 67772.11, 63428.42, 8445.61, 52987.43,
     B140034.35, 15956.74, 177662.25, 16095.99, 367745.21, 1033475.56,
     C17795.56, 52408.94, 1222730.01)

      DATA((VARD(I),I=1,19)= 586.75, 219.45, 158.86, 364.24, 597.99,
     A472.32, 257.51, 329.02, 392.2, 311.59, 289.88, 248.44, 936.36,
     B104.43, 2305.06, 2061.25, 653.62, 525.14, 1694.06)

      DATA((VARU(I),I=1,19)= 342.139, 203.404, 45.469, 34.272, 139.523,
     A69.455, 108.635, 95.912, 89.302, 143.928, 173.633, 174.266, 25.654
     B, 5.317, 10.9733, 2.218, 8.3065, 16.8116, 24.7227)


      DATA((RMSM(I),I=1,19)= 133.7613, 164.5969, 201.2244, 62.91051,
     A285.685, 99.6568, 66.5779, 152.3354, 232.59, 281.0106, 340.4535,
     B273.2079, 1069.803, 116.2075, 718.5064, 599.507, 354.58, 735.976,
     C2514.26)

      DATA((RMSD(I),I=1,19)= 6.7077, 6.498141, 14.31099, 4.2459, 29.859,
     A9.18922, 8.42474, 7.2946, 39.25434, 39.17399, 27.5355, 14.9775,
     B55.5507, 13.4925, 32.452, 120.7981, 43.26675, 54.3363, 199.90)

      DATA((RMSU(I),I=1,19)= 11.8837, 8.72037, 6.83979, 4.2615, 4.9125,
     A4.5647, 5.0965, 7.950317, 5.88204, 17.6811, 14.1378, 11.34036,
     C2.72007, 1.33245, 1.93279, 1.643111, 3.166367, 2.438, 5.9155)

      END




      BLOCK DATA PERCNT
C
C     THIS SUBROUTINE INITIALIZES ARRAY PCT IN COMMON/RRATE/.
C
      COMMON/RRATE/RR(12),VRR(12),PCT(12)
      DATA((PCT(I),I=1,12)= .01, .015, .02, .03, .05, .08, .1, .2, .5,
     1      .8, 1., .001)
      END
```

```
      BLOCK DATA TABLES
C
C     THIS BLOCK DATA SUBROUTINE CONTAINS THE CO-ORDINATES, ELEVATION,
C     AND, THE METEOROLOGICAL DATA OF 359 STATIONS LOCATED WITHIN THE
C        POLITICAL BOUNDARIES OF THE U.S..  THE SUBROUTINE TABLUS
C        UTILIZES THIS DATA BASE TO FIND THE CLOSEST SET OF THESE DATA
C        STATIONS TO THE INTERPOLATED POINT - THE DESIRED LOCATION FOR
C        THE MICROWAVE LINK.  THIS SET OF DATA POINTS IS THEN USED BY
C        THE INTERPOLATION ROUTINE IDBVIP TO INTERPOLATE FOR ANY NEEDED
C        DATA.
C
      COMMON/DATPT/DATAPT(359,10)
C
C.....DESCRIPTION OF THE ARRAY DATAPT
C
C     EACH DATAPT CORRESPONDS TO A STATION LISTED IN THE WRITEUP, (I.E.
C        STATION 1 CORRESPONDS TO DATAPT 1, ETC.).  THUS, FOR
C        STATION (L) THE POSITION, ELEVATION AND METEOROLOGICAL
C        INFORMATION IS CONTAINED IN DATAPT(L,I).  THE INFORMATION IS
C        CODED AS FOLLOWS,
C
C        I=1
C           DECIMAL LATITUDE OF THE STATION
C        I=2
C           DECIMAL LONGITUDE OF THE STATION
C        I=3
C           ELEVATION OF THE STATION
C        I=4
C           AVERAGE ANNUAL PRESSURE OF THE STATION
C        I=5
C           AVERAGE ANNUAL TEMPERATURE OF THE STATION
C        I=6
C           AVERAGE ANNUAL RELATIVE HUMIDITY OF THE STATION
C        I=7
C           AVERAGE ANNUAL PRECIPITATION OF THE STATION - M
C        I=8
C           AVERAGE NUMBER OF DAYS PER YEAR WITH PRECIP. GREATER THAN
C                 .25 MM. - D
C        I=9
C           AVERAGE NUMBER OF THUNDERSTORM DAYS PER YEAR FOR THE
C                 STATION - U
C        I=10
C           GREATEST MONTHLY PRECIPITATION RECORDED IN 30 YEARS - EMAX
C
C
C.....THE BLOCK DATA SUBROUTINE IS PARTITIONED AS FOLLOWS,
C
C        STATIONS NUMBERED 1 - 329 ARE LOCATED IN THE CONTINENTAL U.S.
C        STATIONS NUMBERED 330 - 355 ARE LOCATED IN ALASKA
C        STATIONS NUMBERED 356 - 359 ARE LOCATED IN HAWAII
C
C
C     **************************************************************
C
      DATA(DATAPT(  1,I),I=1,10)/ 33.05, 86.92,  189.00, 991.00, 16.900,
     1 .720,1352.00, 118.00,  58.00, 449.00/
      DATA(DATAPT(  2,I),I=1,10)/ 34.73, 86.58,  193.00, 990.80, 16.000,
     1 .740,1325.00, 122.00,  59.00, 375.00/
      DATA(DATAPT(  3,I),I=1,10)/ 30.07, 80.08,   64.00,1005.70, 19.700,
     1 .730,1701.00, 124.00,  80.00, 490.00/
      DATA(DATAPT(  4,I),I=1,10)/ 32.37, 86.33,   59.00,1006.30, 18.200,
     1 .720,1266.00, 109.00,  62.00, 542.00/
      DATA(DATAPT(  5,I),I=1,10)/ 35.20,111.63, 2135.00, 781.40,  7.400,
     1 .530, 490.00,  75.00,  51.00, 250.00/
      DATA(DATAPT(  6,I),I=1,10)/ 33.50,112.05,  339.00, 974.20, 21.300,
```

```
1 .390, 179.00,  34.00,  23.00, 141.00/
 DATA(DATAPT(  7,I),I=1,10)/ 32.25,110.95,  738.00, 924.40, 19.900,
1 .420, 281.00,  50.00,  40.00, 201.00/
 DATA(DATAPT(  8,I),I=1,10)/ 35.02,110.72, 1492.00, 848.00, 12.900,
1 .510, 186.00,  53.00,  76.00, 142.00/
 DATA(DATAPT(  9,I),I=1,10)/ 32.67,114.65,   59.00,1006.40, 23.200,
1 .380,  68.00,  15.00,   7.00,  68.00/
 DATA(DATAPT( 10,I),I=1,10)/ 35.37, 94.45,  136.00, 997.10, 16.300,
1 .660,1074.00,  96.00,  56.00, 356.00/
 DATA(DATAPT( 11,I),I=1,10)/ 34.70, 92.28,   78.00,1004.00, 16.100,
1 .690,1232.00, 104.00,  58.00, 367.00/
 DATA(DATAPT( 12,I),I=1,10)/ 33.47, 94.03,  119.00, 999.20, 17.900,
1 .690,1249.00,  98.00,  62.00, 423.00/
 DATA(DATAPT( 13,I),I=1,10)/ 35.33,118.87,  145.00, 996.20, 18.300,
1 .530, 145.00,  36.00,   3.00, 117.00/
 DATA(DATAPT( 14,I),I=1,10)/ 37.33,118.40, 1252.00, 872.80, 13.300,
1 .290, 145.00,  29.00,  13.00, 227.00/
 DATA(DATAPT( 15,I),I=1,10)/ 39.10,118.75, 1609.00, 834.60, 10.100,
1 .470,1717.00,  90.00,  12.00,1146.00/
 DATA(DATAPT( 16,I),I=1,10)/ 40.82,124.17,   13.00,1011.70, 11.200,
1 .800,1010.00, 118.00,   5.00, 421.00/
 DATA(DATAPT( 17,I),I=1,10)/ 36.68,119.78,  100.00,1001.40, 16.800,
1 .620, 260.00,  44.00,   6.00, 217.00/
 DATA(DATAPT( 18,I),I=1,10)/ 33.78,118.25,    8.00,1012.30, 17.400,
1 .620, 260.00,  30.00,   4.00, 285.00/
 DATA(DATAPT( 19,I),I=1,10)/ 34.00,118.25,   30.00,1009.70, 16.500,
1 .670, 294.00,  35.00,   3.00, 281.00/
 DATA(DATAPT( 20,I),I=1,10)/ 34.25,118.50,   82.00,1003.60, 18.200,
1 .590, 357.00,  34.00,   6.00, 379.00/
 DATA(DATAPT( 21,I),I=1,10)/ 41.32,122.33, 1080.00, 889.50,  9.800,
1 .600, 952.00,  91.00,  13.00, 447.00/
 DATA(DATAPT( 22,I),I=1,10)/ 37.83,122.25,    2.00,1013.00, 14.100,
1 .770, 475.00,  64.00,   2.00, 287.00/
 DATA(DATAPT( 23,I),I=1,10)/ 40.18,122.27,  104.00,1000.90, 17.100,
1 .520, 560.00,  71.00,  10.00, 289.00/
 DATA(DATAPT( 24,I),I=1,10)/ 38.53,121.50,    5.00,1012.70, 15.700,
1 .670, 437.00,  58.00,   5.00, 321.00/
 DATA(DATAPT( 25,I),I=1,10)/ 34.70,118.60, 1377.00, 859.60, 12.800,
1 .430, 304.00,  40.00,   4.00, 289.00/
 DATA(DATAPT( 26,I),I=1,10)/ 32.75,117.17,    4.00,1012.80, 17.200,
1 .660, 240.00,  41.00,   3.00, 193.00/
 DATA(DATAPT( 27,I),I=1,10)/ 37.75,122.45,    2.00,1013.00, 13.800,
1 .750, 496.00,  62.00,   2.00, 312.00/
 DATA(DATAPT( 28,I),I=1,10)/ 37.92,122.50,   16.00,1011.30, 13.700,
1 .760, 525.00,  68.00,   2.00, 291.00/
 DATA(DATAPT( 29,I),I=1,10)/ 33.42,118.42,  478.00, 957.70, 16.100,
1 .710, 365.00,  42.00,   4.00, 190.00/
 DATA(DATAPT( 30,I),I=1,10)/ 34.93,120.42,   72.00,1004.60, 13.800,
1 .700, 311.00,  45.00,   2.00, 246.00/
 DATA(DATAPT( 31,I),I=1,10)/ 37.98,121.33,    7.00,1012.40, 15.900,
1 .630, 360.00,  52.00,   3.00, 204.00/
 DATA(DATAPT( 32,I),I=1,10)/ 37.47,105.90, 2297.00, 764.50,  5.300,
1 .590, 176.00,  68.00,  44.00,  89.00/
 DATA(DATAPT( 33,I),I=1,10)/ 38.83,104.83, 1873.00, 807.80,  9.100,
1 .490, 400.00,  86.00,  59.00, 203.00/
 DATA(DATAPT( 34,I),I=1,10)/ 39.75,105.00, 1610.00, 834.50, 10.100,
1 .500, 394.00,  88.00,  41.00, 186.00/
 DATA(DATAPT( 35,I),I=1,10)/ 39.07,108.55, 1476.00, 848.90, 11.500,
1 .510, 214.00,  71.00,  35.00,  88.00/
 DATA(DATAPT( 36,I),I=1,10)/ 38.28,104.63, 1428.00, 853.80, 11.600,
1 .500, 303.00,  70.00,  41.00, 157.00/
 DATA(DATAPT( 37,I),I=1,10)/ 41.20, 73.20,    2.00,1013.00, 11.100,
1 .670, 981.00, 118.00,  21.00, 450.00/
 DATA(DATAPT( 38,I),I=1,10)/ 41.75, 72.70,   52.00,1006.90,  9.500,
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1 .640,1102.00, 128.00,  22.00, 555.00/
 DATA(DATAPT( 39,I),I=1,10)/ 41.30, 72.92,   2.00,1013.00, 10.100,
1 .720,1169.00, 128.00,  11.00, 278.00/
 DATA(DATAPT( 40,I),I=1,10)/ 39.77, 75.52,  23.00,1013.50, 12.200,
1 .680,1102.00, 116.00,  31.00, 307.00/
 DATA(DATAPT( 41,I),I=1,10)/ 39.00, 77.00,  88.00,1002.60, 12.100,
1 .710,1019.00, 114.00,  26.00, 462.00/
 DATA(DATAPT( 42,I),I=1,10)/ 38.83, 77.17,   3.00,1012.90, 14.100,
1 .620, 988.00, 112.00,  29.00, 363.00/
 DATA(DATAPT( 43,I),I=1,10)/ 29.72, 85.02,   4.00,1012.78, 20.300,
1 .730,1453.00, 106.00,  70.00, 573.00/
 DATA(DATAPT( 44,I),I=1,10)/ 29.18, 81.02,   9.00,1012.20, 21.400,
1 .770,1276.00, 115.00,  80.00, 505.00/
 DATA(DATAPT( 45,I),I=1,10)/ 26.65, 81.85,   5.00,1012.70, 23.300,
1 .740,1370.00, 113.00,  95.00, 511.00/
 DATA(DATAPT( 46,I),I=1,10)/ 30.33, 81.67,   5.00,1012.30, 20.200,
1 .730,1384.00, 116.00,  64.00, 492.00/
 DATA(DATAPT( 47,I),I=1,10)/ 24.57, 81.80,   1.00,1013.10, 25.700,
1 .740,1016.00, 112.00,  62.00, 548.00/
 DATA(DATAPT( 48,I),I=1,10)/ 28.03, 81.95,  65.00,1005.70, 22.300,
1 .740,1256.00, 120.00, 100.00, 398.00/
 DATA(DATAPT( 49,I),I=1,10)/ 25.75, 80.25,   2.00,1013.00, 24.200,
1 .730,1519.00, 129.00,  75.00, 620.00/
 DATA(DATAPT( 50,I),I=1,10)/ 28.55, 81.35,  29.00,1009.90, 22.100,
1 .730,1301.00, 115.00,  80.00, 388.00/
 DATA(DATAPT( 51,I),I=1,10)/ 30.43, 87.20,  34.00,1009.20, 20.000,
1 .740,1631.00, 116.00,  74.00, 407.00/
 DATA(DATAPT( 52,I),I=1,10)/ 30.43, 84.32,  17.00,1011.20, 19.600,
1 .760,1564.00, 119.00,  86.00, 511.00/
 DATA(DATAPT( 53,I),I=1,10)/ 27.97, 82.63,   6.00,1012.50, 22.300,
1 .740,1254.00, 107.00,  88.00, 523.00/
 DATA(DATAPT( 54,I),I=1,10)/ 26.70, 80.08,   5.00,1012.70, 23.600,
1 .730,1576.00, 131.00,  79.00, 631.00/
 DATA(DATAPT( 55,I),I=1,10)/ 33.95, 83.40, 244.00, 984.50, 16.400,
1 .720,1285.00, 112.00,  51.00, 380.00/
 DATA(DATAPT( 56,I),I=1,10)/ 33.75, 84.38, 308.00, 977.10, 16.000,
1 .720,1228.00, 116.00,  50.00, 399.00/
 DATA(DATAPT( 57,I),I=1,10)/ 33.48, 82.00,  41.00,1008.40, 17.400,
1 .710,1083.00, 107.00,  56.00, 290.00/
 DATA(DATAPT( 58,I),I=1,10)/ 32.47, 84.98, 117.00, 999.40, 17.900,
1 .730,1294.00, 112.00,  59.00, 336.00/
 DATA(DATAPT( 59,I),I=1,10)/ 32.82, 83.62, 108.00,1000.50, 18.400,
1 .710,1129.00, 112.00,  57.00, 299.00/
 DATA(DATAPT( 60,I),I=1,10)/ 34.02, 85.03, 194.00, 990.30, 15.700,
1 .700,1336.00, 123.00,  61.00, 441.00/
 DATA(DATAPT( 61,I),I=1,10)/ 32.07, 81.12,  14.00,1011.60, 18.800,
1 .730,1299.00, 112.00,  64.00, 511.00/
 DATA(DATAPT( 62,I),I=1,10)/ 43.63,116.20, 865.00, 913.10, 10.500,
1 .550, 292.00,  91.00,  15.00, 102.00/
 DATA(DATAPT( 63,I),I=1,10)/ 43.83,112.02,1460.00, 847.20,  5.400,
1 .580, 178.00,  66.00,  13.00, 128.00/
 DATA(DATAPT( 64,I),I=1,10)/ 43.50,112.02,1503.00, 843.00,  5.800,
1 .580, 192.00,  68.00,  13.00, 112.00/
 DATA(DATAPT( 65,I),I=1,10)/ 46.42,117.00, 431.00, 962.10, 10.900,
1 .580, 336.00, 103.00,  16.00, 122.00/
 DATA(DATAPT( 66,I),I=1,10)/ 42.88,112.43,1358.00, 859.30,  8.200,
1 .550, 274.00,  94.00,  24.00, 101.00/
 DATA(DATAPT( 67,I),I=1,10)/ 37.02, 89.15,  96.00,1001.80, 15.200,
1 .730,1197.00, 115.00,  53.00, 380.00/
 DATA(DATAPT( 68,I),I=1,10)/ 42.00, 87.83, 201.00, 988.90,  9.400,
1 .690, 806.00, 126.00,  38.00, 291.00/
 DATA(DATAPT( 69,I),I=1,10)/ 41.83, 87.75, 185.00, 990.90, 10.300,
1 .660, 875.00, 123.00,  39.00, 360.00/
 DATA(DATAPT( 70,I),I=1,10)/ 41.52, 90.43, 177.00, 991.80,  9.900,
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1 .680, 909.00, 112.00,  48.00, 360.00/
 DATA(DATAPT( 71,I),I=1,10)/ 40.72, 89.63,  199.00, 989.30, 10.400,
1 .710, 891.00, 112.00,  49.00, 332.00/
 DATA(DATAPT( 72,I),I=1,10)/ 42.27, 89.10,  221.00, 986.50,  8.900,
1 .700, 933.00, 115.00,  42.00, 300.00/
 DATA(DATAPT( 73,I),I=1,10)/ 39.82, 89.65,  179.00, 991.70, 11.500,
1 .690, 890.00, 113.00,  50.00, 252.00/
 DATA(DATAPT( 74,I),I=1,10)/ 38.00, 87.55,  116.00, 999.30, 13.300,
1 .690,1064.00, 115.00,  46.00, 343.00/
 DATA(DATAPT( 75,I),I=1,10)/ 41.08, 85.13,  241.00, 984.20,  9.900,
1 .700, 909.00, 132.00,  41.00, 247.00/
 DATA(DATAPT( 76,I),I=1,10)/ 39.75, 86.17,  241.00, 984.40, 11.300,
1 .670, 984.00, 123.00,  45.00, 322.00/
 DATA(DATAPT( 77,I),I=1,10)/ 41.67, 86.25,  236.00, 984.80,  9.500,
1 .720, 919.00, 142.00,  43.00, 248.00/
 DATA(DATAPT( 78,I),I=1,10)/ 40.83, 91.12,  211.00, 987.80, 10.400,
1 .710, 980.00, 104.00,  51.00, 384.00/
 DATA(DATAPT( 79,I),I=1,10)/ 41.58, 93.58,  286.00, 978.80,  9.400,
1 .690, 784.00, 106.00,  50.00, 360.00/
 DATA(DATAPT( 80,I),I=1,10)/ 42.52, 90.68,  322.00, 974.40,  8.100,
1 .710,1023.00, 114.00,  45.00, 393.00/
 DATA(DATAPT( 81,I),I=1,10)/ 42.50, 96.47,  334.00, 973.10,  9.100,
1 .700, 654.00,  99.00,  46.00, 262.00/
 DATA(DATAPT( 82,I),I=1,10)/ 42.50, 92.33,  265.00, 981.20,  8.000,
1 .710, 857.00,  98.00,  41.00, 320.00/
 DATA(DATAPT( 83,I),I=1,10)/ 39.58, 97.65,  448.00, 960.30, 11.700,
1 .670, 701.00,  90.00,  59.00, 359.00/
 DATA(DATAPT( 84,I),I=1,10)/ 37.75,100.03,  787.00, 922.30, 12.700,
1 .590, 523.00,  78.00,  53.00, 232.00/
 DATA(DATAPT( 85,I),I=1,10)/ 39.33,101.72, 1114.00, 886.00, 10.300,
1 .600, 423.00,  76.00,  49.00, 205.00/
 DATA(DATAPT( 86,I),I=1,10)/ 39.03, 95.68,  267.00, 981.40, 12.400,
1 .680, 880.00,  95.00,  58.00, 386.00/
 DATA(DATAPT( 87,I),I=1,10)/ 37.72, 97.33,  403.00, 965.80, 13.700,
1 .640, 777.00,  84.00,  55.00, 266.00/
 DATA(DATAPT( 88,I),I=1,10)/ 39.07, 84.50,  265.00, 981.60, 12.200,
1 .640, 992.00, 129.00,  44.00, 309.00/
 DATA(DATAPT( 89,I),I=1,10)/ 38.03, 84.50,  294.00, 978.30, 12.900,
1 .700,1130.00, 131.00,  47.00, 423.00/
 DATA(DATAPT( 90,I),I=1,10)/ 38.22, 85.80,  145.00, 995.90, 13.100,
1 .680,1095.00, 125.00,  45.00, 379.00/
 DATA(DATAPT( 91,I),I=1,10)/ 31.32, 92.48,   28.00,1009.90, 18.300,
1 .760,1373.00, 107.00,  69.00, 332.00/
 DATA(DATAPT( 92,I),I=1,10)/ 30.50, 91.17,   20.00,1010.90, 19.700,
1 .740,1373.00, 107.00,  70.00, 369.00/
 DATA(DATAPT( 93,I),I=1,10)/ 30.22, 93.22,    3.00,1012.90, 20.200,
1 .780,1409.00,  96.00,  78.00, 507.00/
 DATA(DATAPT( 94,I),I=1,10)/ 30.00, 90.05,    1.00,1013.10, 20.200,
1 .760,1442.00, 114.00,  69.00, 485.00/
 DATA(DATAPT( 95,I),I=1,10)/ 32.50, 93.77,   77.00,1004.20, 18.800,
1 .690,1136.00,  97.00,  54.00, 315.00/
 DATA(DATAPT( 96,I),I=1,10)/ 46.87, 68.02,  190.00, 989.60,  3.800,
1 .710, 910.00, 160.00,  20.00, 215.00/
 DATA(DATAPT( 97,I),I=1,10)/ 43.68, 70.30,   13.00,1011.60,  7.200,
1 .710,1036.00, 127.00,  18.00, 312.00/
 DATA(DATAPT( 98,I),I=1,10)/ 39.30, 76.63,   45.00,1007.80, 12.800,
1 .650,1028.00, 113.00,  28.00, 466.00/
 DATA(DATAPT( 99,I),I=1,10)/ 42.22, 71.12,  192.00, 990.00,  9.300,
1 .700,1189.00, 135.00,  19.00, 477.00/
 DATA(DATAPT(100,I),I=1,10)/ 42.33, 71.08,    5.00,1012.60, 10.700,
1 .630,1080.00, 128.00,  19.00, 434.00/
 DATA(DATAPT(101,I),I=1,10)/ 41.28, 70.08,   13.00,1011.70,  9.700,
1 .790,1101.00, 125.00,  20.00, 328.00/
 DATA(DATAPT(102,I),I=1,10)/ 42.45, 73.25,  357.00, 970.10,  7.200,
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1 .680,1128.00, 152.00,  28.00, 262.00/
 DATA(DATAPT(103,I),I=1,10)/ 42.28, 71.80,  301.00, 976.90,  8.400,
1 .660,1149.00, 128.00,  21.00, 334.00/
 DATA(DATAPT(104,I),I=1,10)/ 45.07, 83.45,  210.00, 987.50,  5.600,
1 .690, 701.00, 146.00,  34.00, 213.00/
 DATA(DATAPT(105,I),I=1,10)/ 42.38, 83.08,  189.00, 990.40,  9.900,
1 .670, 786.00, 131.00,  32.00, 204.00/
 DATA(DATAPT(106,I),I=1,10)/ 42.17, 83.50,  193.00, 989.90,  9.500,
1 .690, 805.00, 133.00,  33.00, 199.00/
 DATA(DATAPT(107,I),I=1,10)/ 42.25, 82.92,  217.00, 987.10, 10.000,
1 .670, 779.00, 125.00,  33.00, 221.00/
 DATA(DATAPT(108,I),I=1,10)/ 43.05, 83.67,  235.00, 984.80,  6.200,
1 .690, 756.00, 132.00,  33.00, 280.00/
 DATA(DATAPT(109,I),I=1,10)/ 42.95, 86.67,  239.00, 984.30,  8.800,
1 .710, 823.00, 145.00,  38.00, 209.00/
 DATA(DATAPT(110,I),I=1,10)/ 47.10, 88.57,  350.00, 970.80,  5.900,
1 .720, 721.00, 146.00,  40.00, 182.00/
 DATA(DATAPT(111,I),I=1,10)/ 42.73, 85.57,  256.00, 982.30,  8.600,
1 .720, 772.00, 139.00,  34.00, 249.00/
 DATA(DATAPT(112,I),I=1,10)/ 46.55, 87.38,  206.00, 988.00,  5.900,
1 .700, 783.00, 158.00,  28.00, 259.00/
 DATA(DATAPT(113,I),I=1,10)/ 43.22, 86.25,  191.00, 990.10,  8.500,
1 .720, 801.00, 143.00,  38.00, 251.00/
 DATA(DATAPT(114,I),I=1,10)/ 46.48, 84.37,  220.00, 986.20,  4.400,
1 .760, 805.00, 164.00,  30.00, 241.00/
 DATA(DATAPT(115,I),I=1,10)/ 46.75, 92.17,  435.00, 960.30,  3.700,
1 .690, 767.00, 135.00,  35.00, 262.00/
 DATA(DATAPT(116,I),I=1,10)/ 48.63, 93.43,  359.00, 969.20,  2.500,
1 .680, 652.00, 133.00,  31.00, 286.00/
 DATA(DATAPT(117,I),I=1,10)/ 45.00, 93.25,  254.00, 982.30,  6.700,
1 .670, 659.00, 113.00,  36.00, 204.00/
 DATA(DATAPT(118,I),I=1,10)/ 44.02, 92.45,  395.00, 965.50,  6.400,
1 .720, 698.00, 117.00,  42.00, 212.00/
 DATA(DATAPT(119,I),I=1,10)/ 45.57, 94.17,  313.00, 975.10,  5.400,
1 .690, 682.00, 108.00,  36.00, 237.00/
 DATA(DATAPT(120,I),I=1,10)/ 32.33, 90.16,   94.00,1002.20, 18.300,
1 .740,1249.00, 113.00,  65.00, 302.00/
 DATA(DATAPT(121,I),I=1,10)/ 32.35, 88.70,   88.00,1002.90, 18.100,
1 .720,1310.00, 104.00,  59.00, 427.00/
 DATA(DATAPT(122,I),I=1,10)/ 32.35, 90.85,   71.00,1004.90, 18.800,
1 .740,1257.00, 105.00,  62.00, 421.00/
 DATA(DATAPT(123,I),I=1,10)/ 38.97, 92.33,  237.00, 985.00, 12.800,
1 .680, 939.00, 107.00,  55.00, 338.00/
 DATA(DATAPT(124,I),I=1,10)/ 38.47, 92.83,  270.00, 961.10, 12.400,
1 .670, 950.00, 115.00,  53.00, 256.00/
 DATA(DATAPT(125,I),I=1,10)/ 39.03, 94.55,  309.00, 976.50, 12.500,
1 .630, 940.00, 104.00,  49.00, 262.00/
 DATA(DATAPT(126,I),I=1,10)/ 39.37, 94.88,  226.00, 986.40, 13.800,
1 .630, 865.00, 104.00,  49.00, 303.00/
 DATA(DATAPT(127,I),I=1,10)/ 39.75, 94.85,  247.00, 983.70, 12.100,
1 .660, 906.00,  95.00,  56.00, 349.00/
 DATA(DATAPT(128,I),I=1,10)/ 37.18, 93.32,  386.00, 967.70, 13.400,
1 .670,1008.00, 108.00,  59.00, 476.00/
 DATA(DATAPT(129,I),I=1,10)/ 45.78,108.50, 1087.00, 887.90,  7.900,
1 .520, 359.00,  95.00,  29.00, 194.00/
 DATA(DATAPT(130,I),I=1,10)/ 48.20,106.62,  696.00, 930.40,  5.300,
1 .600, 276.00,  89.00,  27.00, 136.00/
 DATA(DATAPT(131,I),I=1,10)/ 47.50,111.27, 1116.00, 884.50,  7.200,
1 .530, 381.00, 100.00,  26.00, 207.00/
 DATA(DATAPT(132,I),I=1,10)/ 48.57,109.67,  788.00, 920.10,  5.700,
1 .570, 293.00,  86.00,  22.00, 127.00/
 DATA(DATAPT(133,I),I=1,10)/ 46.58,112.00, 1167.00, 878.60,  6.200,
1 .550, 289.00,  96.00,  34.00, 120.00/
 DATA(DATAPT(134,I),I=1,10)/ 48.20,114.32,  904.00, 904.00,  5.400,
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1 .650, 412.00, 132.00,  24.00, 120.00/
 DATA(DATAPT(135,I),I=1,10)/ 46.40,105.80,  801.00, 919.10,  7.400,
1 .580, 354.00,  94.00,  28.00, 248.00/
 DATA(DATAPT(136,I),I=1,10)/ 46.87,114.00,  972.00, 899.90,  6.500,
1 .650, 339.00, 124.00,  24.00, 136.00/
 DATA(DATAPT(137,I),I=1,10)/ 40.93, 98.35,  561.00, 947.00, 10.100,
1 .650, 595.00,  88.00,  49.00, 355.00/
 DATA(DATAPT(138,I),I=1,10)/ 40.82, 96.68,  359.00, 970.40, 10.600,
1 .640, 677.00,  94.00,  46.00, 191.00/
 DATA(DATAPT(139,I),I=1,10)/ 41.00, 96.00,  351.00, 971.50, 11.600,
1 .640, 697.00,  96.00,  49.00, 328.00/
 DATA(DATAPT(140,I),I=1,10)/ 42.02, 97.42,  471.00, 957.10,  9.100,
1 .660, 618.00,  87.00,  50.00, 310.00/
 DATA(DATAPT(141,I),I=1,10)/ 41.15,100.75,  846.00, 914.70,  9.200,
1 .650, 505.00,  83.00,  48.00, 203.00/
 DATA(DATAPT(142,I),I=1,10)/ 41.25, 96.00,  298.00, 977.60, 10.800,
1 .670, 767.00, 100.00,  48.00, 349.00/
 DATA(DATAPT(143,I),I=1,10)/ 41.87,103.67, 1206.00, 875.70,  9.000,
1 .580, 370.00,  84.00,  43.00, 212.00/
 DATA(DATAPT(144,I),I=1,10)/ 42.88,100.52,  789.00, 920.80,  8.300,
1 .620, 452.00,  78.00,  45.00, 228.00/
 DATA(DATAPT(145,I),I=1,10)/ 40.83,115.77, 1539.00, 840.20,  7.400,
1 .500, 248.00,  78.00,  21.00, 117.00/
 DATA(DATAPT(146,I),I=1,10)/ 39.25,114.88, 1906.00, 803.00,  6.700,
1 .470, 221.00,  72.00,  32.00,  90.00/
 DATA(DATAPT(147,I),I=1,10)/ 36.17,115.17,  659.00, 938.10, 18.800,
1 .300,  96.00,  24.00,  15.00,  66.00/
 DATA(DATAPT(148,I),I=1,10)/ 39.53,119.82, 1342.00, 861.70,  9.700,
1 .510, 183.00,  50.00,  13.00, 133.00/
 DATA(DATAPT(149,I),I=1,10)/ 40.97,117.75, 1311.00, 864.50,  8.800,
1 .480, 215.00,  67.00,  15.00,  73.00/
 DATA(DATAPT(150,I),I=1,10)/ 43.22, 71.57,  104.00,1000.50,  7.600,
1 .680, 919.00, 125.00,  21.00, 257.00/
 DATA(DATAPT(151,I),I=1,10)/ 44.27, 71.30, 1909.00, 796.20, -2.800,
1 .860,1935.00, 207.00,  16.00, 649.00/
 DATA(DATAPT(152,I),I=1,10)/ 40.73, 74.18,    2.00,1013.00, 12.200,
1 .630,1053.00, 123.00,  26.00, 301.00/
 DATA(DATAPT(153,I),I=1,10)/ 40.25, 74.72,   17.00,1011.20, 12.200,
1 .650,1020.00, 122.00,  33.00, 358.00/
 DATA(DATAPT(154,I),I=1,10)/ 35.08,106.63, 1619.00, 835.70, 13.800,
1 .460, 197.00,  57.00,  43.00,  85.00/
 DATA(DATAPT(155,I),I=1,10)/ 36.45,103.20, 1515.00, 844.90, 11.500,
1 .520, 404.00,  67.00,  54.00, 197.00/
 DATA(DATAPT(156,I),I=1,10)/ 36.90,104.45, 1944.00, 801.10,  9.400,
1 .420, 375.00,  78.00,  75.00, 303.00/
 DATA(DATAPT(157,I),I=1,10)/ 33.40,104.55, 1101.00, 889.20, 14.700,
1 .500, 295.00,  50.00,  40.00, 103.00/
 DATA(DATAPT(158,I),I=1,10)/ 33.67,104.83, 1112.00, 888.70, 16.200,
1 .540, 269.00,  48.00,  30.00, 165.00/
 DATA(DATAPT(159,I),I=1,10)/ 32.78,108.27, 1638.00, 834.30, 14.600,
1 .390, 273.00,  60.00,  54.00, 114.00/
 DATA(DATAPT(160,I),I=1,10)/ 42.67, 73.82,   84.00,1003.00,  8.700,
1 .690, 847.00, 135.00,  28.00, 228.00/
 DATA(DATAPT(161,I),I=1,10)/ 42.10, 75.92,  485.00, 955.30,  7.800,
1 .730, 949.00, 163.00,  31.00, 240.00/
 DATA(DATAPT(162,I),I=1,10)/ 42.17, 76.00,  262.00, 981.70,  9.300,
1 .730, 932.00, 151.00,  31.00, 244.00/
 DATA(DATAPT(163,I),I=1,10)/ 42.87, 78.92,  215.00, 987.20,  8.400,
1 .700, 917.00, 168.00,  30.00, 232.00/
 DATA(DATAPT(164,I),I=1,10)/ 40.83, 74.00,   40.00,1008.40, 12.500,
1 .640,1021.00, 121.00,  20.00, 428.00/
 DATA(DATAPT(165,I),I=1,10)/ 40.67, 73.67,    4.00,1012.80, 11.700,
1 .660,1055.00, 118.00,  22.00, 442.00/
 DATA(DATAPT(166,I),I=1,10)/ 40.75, 73.87,    3.00,1012.90, 12.400,
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1 .610,1057.00, 120.00,  24.00, 408.00/
 DATA(DATAPT(167,I),I=1,10)/ 43.20, 77.62,  167.00, 993.00,  8.800,
1 .680, 796.00, 154.00,  29.00, 246.00/
 DATA(DATAPT(168,I),I=1,10)/ 43.05, 76.17,  125.00, 998.00,  8.900,
1 .690, 925.00, 167.00,  29.00, 312.00/
 DATA(DATAPT(169,I),I=1,10)/ 35.58, 82.58,  652.00, 937.50, 13.200,
1 .760,1148.00, 129.00,  50.00, 287.00/
 DATA(DATAPT(170,I),I=1,10)/ 35.23, 75.52,    2.00,1013.00, 16.500,
1 .780.1413.00, 123.00,  45.00, 372.00/
 DATA(DATAPT(171,I),I=1,10)/ 35.05, 80.83,  224.00, 986.80, 15.800,
1 .690,1085.00, 112.00,  42.00, 317.00/
 DATA(DATAPT(172,I),I=1,10)/ 36.05, 79.83,  273.00, 980.00, 14.500,
1 .720,1051.00, 118.00,  47.00, 337.00/
 DATA(DATAPT(173,I),I=1,10)/ 35.77, 78.65,  132.00, 997.50, 15.100,
1 .710,1081.00, 113.00,  46.00, 329.00/
 DATA(DATAPT(174,I),I=1,10)/ 34.23, 77.92,    9.00,1012.20, 17.600,
1 .740,1361.00, 119.00,  46.00, 394.00/
 DATA(DATAPT(175,I),I=1,10)/ 46.83,100.80,  502.00, 952.70,  5.200,
1 .640, 410.00,  96.00,  34.00, 211.00/
 DATA(DATAPT(176,I),I=1,10)/ 46.87, 96.82,  273.00, 979.80,  4.900,
1 .680, 498.00, 103.00,  34.00, 239.00/
 DATA(DATAPT(177,I),I=1,10)/ 48.15,103.65,  579.00, 943.70,  4.900,
1 .650, 364.00,  95.00,  26.00, 187.00/
 DATA(DATAPT(178,I),I=1,10)/ 41.07, 81.52,  366.00, 969.24,  9.800,
1 .700, 892.00, 153.00,  40.00, 290.00/
 DATA(DATAPT(179,I),I=1,10)/ 39.17, 84.50,  232.00, 985.60, 12.700,
1 .690,1017.00, 132.00,  50.00, 347.00/
 DATA(DATAPT(180,I),I=1,10)/ 41.50, 81.68,  237.00, 984.70,  9.800,
1 .690, 889.00, 156.00,  36.00, 241.00/
 DATA(DATAPT(181,I),I=1,10)/ 39.98, 83.05,  247.00, 983.60, 10.800,
1 .680, 940.00, 136.00,  42.00, 248.00/
 DATA(DATAPT(182,I),I=1,10)/ 39.75, 84.17,  303.00, 977.00, 11.100,
1 .670, 873.00, 130.00,  41.00, 277.00/
 DATA(DATAPT(183,I),I=1,10)/ 40.77, 82.52,  395.00, 966.20, 10.700,
1 .710, 855.00, 140.00,  40.00, 205.00/
 DATA(DATAPT(184,I),I=1,10)/ 41.67, 83.58,  204.00, 988.60,  9.600,
1 .700, 800.00, 136.00,  40.00, 215.00/
 DATA(DATAPT(185,I),I=1,10)/ 41.08, 80.67,  359.00, 970.20,  9.300,
1 .720, 965.00, 163.00,  36.00, 251.00/
 DATA(DATAPT(186,I),I=1,10)/ 35.47, 97.55,  392.00, 967.30, 15.500,
1 .640, 797.00,  82.00,  51.00, 274.00/
 DATA(DATAPT(187,I),I=1,10)/ 36.12, 95.97,  198.00, 989.80, 15.700,
1 .640, 937.00,  90.00,  53.00, 478.00/
 DATA(DATAPT(188,I),I=1,10)/ 46.20,123.83,    2.00,1013.00, 10.300,
1 .810,1685.00, 199.00,   8.00, 556.00/
 DATA(DATAPT(189,I),I=1,10)/ 43.60,119.05, 1265.00, 868.90,  7.800,
1 .560, 300.00,  91.00,  14.00, 146.00/
 DATA(DATAPT(190,I),I=1,10)/ 44.05,123.07,  109.00,1000.10, 11.400,
1 .730,1081.00, 138.00,   5.00, 533.00/
 DATA(DATAPT(191,I),I=1,10)/ 45.52,118.43, 1234.00, 871.50,  6.500,
1 .620, 830.00, 146.00,  16.00, 262.00/
 DATA(DATAPT(192,I),I=1,10)/ 42.33,122.87,  396.00, 966.30, 11.700,
1 .650, 524.00, 102.00,   8.00, 323.00/
 DATA(DATAPT(193,I),I=1,10)/ 45.67,118.77,  452.00, 959.70, 11.300,
1 .450, 313.00, 100.00,  10.00, 119.00/
 DATA(DATAPT(194,I),I=1,10)/ 45.53,122.67,    6.00,1012.50, 11.400,
1 .720, 955.00, 153.00,   7.00, 326.00/
 DATA(DATAPT(195,I),I=1,10)/ 44.95,123.17,   60.00,1006.00, 11.300,
1 .710,1043.00, 150.00,   6.00, 391.00/
 DATA(DATAPT(196,I),I=1,10)/ 42.60,123.50, 1169.00, 879.50,  8.700,
1 .670, 934.00, 130.00,   6.00, 612.00/
 DATA(DATAPT(197,I),I=1,10)/ 40.62, 75.50,  118.00, 999.00, 10.600,
1 .670,1079.00, 124.00,  33.00, 307.00/
 DATA(DATAPT(198,I),I=1,10)/ 42.12, 80.08,  223.00, 986.20,  8.400,
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1 .710, 970.00, 160.00,  39.00, 251.00/
 DATA(DATAPT(199,I),I=1,10)/ 40.28, 76.90,  103.00,1000.80, 11.900,
1 .640, 926.00, 125.00,  33.00, 471.00/
 DATA(DATAPT(200,I),I=1,10)/ 40.00, 75.17,    2.00,1013.00, 12.600,
1 .660,1014.00, 116.00,  27.00, 246.00/
 DATA(DATAPT(201,I),I=1,10)/ 40.43, 80.00,  347.00, 971.80, 10.200,
1 .670, 920.00, 153.00,  36.00, 208.00/
 DATA(DATAPT(202,I),I=1,10)/ 40.50, 80.42,  228.00, 985.90, 11.700,
1 .670, 920.00, 147.00,  36.00, 225.00/
 DATA(DATAPT(203,I),I=1,10)/ 40.33, 75.92,   81.00,1003.50, 12.400,
1 .730,1052.00, 122.00,  32.00, 377.00/
 DATA(DATAPT(204,I),I=1,10)/ 41.42, 75.67,  283.00, 979.20,  9.700,
1 .680, 884.00, 140.00,  31.00, 198.00/
 DATA(DATAPT(205,I),I=1,10)/ 41.27, 77.05,  160.00, 993.90, 10.200,
1 .690,1016.00, 144.00,  34.00, 427.00/
 DATA(DATAPT(206,I),I=1,10)/ 41.18, 71.57,   34.00,1009.10, 10.100,
1 .740,1029.00, 111.00,  17.00, 292.00/
 DATA(DATAPT(207,I),I=1,10)/ 41.83, 71.42,   16.00,1011.30, 10.000,
1 .660,1086.00, 125.00,  20.00, 302.00/
 DATA(DATAPT(208,I),I=1,10)/ 32.80, 79.97,   12.00,1011.80, 18.200,
1 .740,1324.00, 115.00,  57.00, 692.00/
 DATA(DATAPT(209,I),I=1,10)/ 34.00, 81.00,   65.00,1005.50, 17.500,
1 .720,1178.00, 111.00,  55.00, 425.00/
 DATA(DATAPT(210,I),I=1,10)/ 34.87, 82.42,  292.00, 978.90, 15.900,
1 .690,1208.00, 119.00,  44.00, 296.00/
 DATA(DATAPT(211,I),I=1,10)/ 45.47, 98.50,  395.00, 965.50,  6.000,
1 .660, 485.00,  87.00,  37.00, 226.00/
 DATA(DATAPT(212,I),I=1,10)/ 44.37, 98.20,  390.00, 966.20,  7.100,
1 .660, 494.00,  93.00,  41.00, 211.00/
 DATA(DATAPT(213,I),I=1,10)/ 44.10,103.23,  964.00, 901.40,  8.100,
1 .580, 435.00,  95.00,  42.00, 187.00/
 DATA(DATAPT(214,I),I=1,10)/ 43.57, 96.70,  432.00, 961.40,  7.400,
1 .660, 628.00,  94.00,  44.00, 231.00/
 DATA(DATAPT(215,I),I=1,10)/ 36.58, 82.20,  459.00, 959.30, 13.400,
1 .720,1053.00, 134.00,  46.00, 247.00/
 DATA(DATAPT(216,I),I=1,10)/ 35.03, 85.30,  203.00, 989.20, 15.400,
1 .710,1319.00, 121.00,  56.00, 351.00/
 DATA(DATAPT(217,I),I=1,10)/ 36.00, 83.95,  299.00, 978.00, 15.400,
1 .710,1173.00, 128.00,  48.00, 298.00/
 DATA(DATAPT(218,I),I=1,10)/ 35.17, 90.00,   79.00,1003.90, 16.400,
1 .690,1247.00, 107.00,  53.00, 312.00/
 DATA(DATAPT(219,I),I=1,10)/ 36.17, 86.83,  180.00, 991.90, 15.200,
1 .710,1168.00, 119.00,  56.00, 354.00/
 DATA(DATAPT(220,I),I=1,10)/ 36.03, 84.20,  276.00, 980.60, 14.300,
1 .710,1336.00, 129.00,  53.00, 489.00/
 DATA(DATAPT(221,I),I=1,10)/ 32.45, 99.75,  544.00, 950.70, 18.100,
1 .550, 599.00,  65.00,  42.00, 335.00/
 DATA(DATAPT(222,I),I=1,10)/ 35.23,101.83, 1098.00, 889.30, 14.100,
1 .530, 515.00,  68.00,  48.00, 273.00/
 DATA(DATAPT(223,I),I=1,10)/ 30.30, 97.78,  182.00, 992.00, 20.100,
1 .630, 825.00,  82.00,  41.00, 313.00/
 DATA(DATAPT(224,I),I=1,10)/ 25.90, 97.50,    6.00,1012.50, 23.200,
1 .730, 637.00,  72.00,  24.00, 489.00/
 DATA(DATAPT(225,I),I=1,10)/ 27.78, 97.43,   12.00,1011.80, 22.200,
1 .750, 725.00,  77.00,  31.00, 516.00/
 DATA(DATAPT(226,I),I=1,10)/ 32.75, 97.00,  168.00, 993.50, 18.600,
1 .630, 820.00,  79.00,  45.00, 321.00/
 DATA(DATAPT(227,I),I=1,10)/ 32.78, 96.80,  147.00, 996.00, 18.800,
1 .610, 878.00,  80.00,  40.00, 391.00/
 DATA(DATAPT(228,I),I=1,10)/ 29.38,100.93,  313.00, 977.10, 21.100,
1 .570, 429.00,  60.00,  34.00, 401.00/
 DATA(DATAPT(229,I),I=1,10)/ 31.75,106.50, 1194.00, 880.60, 17.400,
1 .450, 197.00,  45.00,  36.00, 170.00/
 DATA(DATAPT(230,I),I=1,10)/ 29.28, 94.80,    2.00,1013.00, 21.000,
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1 .780,1072.00,  96.00,  65.50, 661.00/
 DATA(DATAPT(231,I),I=1,10)/ 29.58, 95.25,   29.00,1009.80, 20.500,
1 .740,1224.00, 108.00,  72.00, 366.00/
 DATA(DATAPT(232,I),I=1,10)/ 29.75, 95.83,   12.00,1011.80, 21.100,
1 .730,1150.00, 104.00,  72.00, 448.00/
 DATA(DATAPT(233,I),I=1,10)/ 29.75, 95.42,   15.00,1011.50, 20.700,
1 .720,1167.00, 103.00,  59.00, 567.00/
 DATA(DATAPT(234,I),I=1,10)/ 33.58,101.88,  992.00, 901.00, 15.400,
1 .550, 468.00,  60.00,  45.00, 225.00/
 DATA(DATAPT(235,I),I=1,10)/ 32.00,102.15,  869.00, 915.00, 17.700,
1 .500, 343.00,  51.00,  36.00, 196.00/
 DATA(DATAPT(236,I),I=1,10)/ 27.83, 97.08,    5.00,1012.70, 20.300,
1 .780,1399.00, 105.00,  65.00, 475.00/
 DATA(DATAPT(237,I),I=1,10)/ 31.47,100.47,  580.00, 946.80, 19.000,
1 .540, 445.00,  56.00,  36.00, 234.00/
 DATA(DATAPT(238,I),I=1,10)/ 29.42, 98.50,  242.00, 985.40, 20.400,
1 .630, 700.00,  83.00,  36.00, 401.00/
 DATA(DATAPT(239,I),I=1,10)/ 28.82, 97.02,   32.00,1009.50, 21.200,
1 .710, 871.00,  86.00,  48.00, 369.00/
 DATA(DATAPT(240,I),I=1,10)/ 31.55, 97.17,  153.00, 995.30, 19.500,
1 .630, 794.00,  77.00,  46.00, 381.00/
 DATA(DATAPT(241,I),I=1,10)/ 33.92, 98.50,  303.00, 977.90, 17.800,
1 .590, 691.00,  69.00,  49.00, 306.00/
 DATA(DATAPT(242,I),I=1,10)/ 32.10, 96.93, 1533.00, 842.00,  9.600,
1 .430, 213.00,  63.00,  32.00,  66.00/
 DATA(DATAPT(243,I),I=1,10)/ 40.75,111.92, 1286.00, 868.00, 10.600,
1 .520, 385.00,  88.00,  35.00, 124.00/
 DATA(DATAPT(244,I),I=1,10)/ 40.75,114.03, 1291.00, 867.80, 11.200,
1 .440, 124.00,  48.00,  29.00,  76.00/
 DATA(DATAPT(245,I),I=1,10)/ 44.47, 73.23,  101.00,1000.90,  6.900,
1 .660, 827.00, 152.00,  25.00, 293.00/
 DATA(DATAPT(246,I),I=1,10)/ 37.40, 79.15,  279.00, 980.10, 13.500,
1 .670, 972.00, 120.00,  41.00, 289.00/
 DATA(DATAPT(247,I),I=1,10)/ 36.90, 76.30,    7.00,1012.40, 15.200,
1 .700,1135.00, 116.00,  37.00, 349.00/
 DATA(DATAPT(248,I),I=1,10)/ 37.57, 77.45,   50.00,1007.30, 14.300,
1 .700,1082.00, 114.00,  37.00, 479.00/
 DATA(DATAPT(249,I),I=1,10)/ 37.25, 79.97,  350.00, 971.90, 13.300,
1 .640, 991.00, 121.00,  38.00, 232.00/
 DATA(DATAPT(250,I),I=1,10)/ 47.05,122.88,   59.00,1006.10, 10.100,
1 .770,1289.00, 183.00,   5.00, 504.00/
 DATA(DATAPT(251,I),I=1,10)/ 47.95,124.55,   55.00,1006.50,  9.300,
1 .820,2667.00, 216.00,   8.00, 690.00/
 DATA(DATAPT(252,I),I=1,10)/ 47.58,122.33,    6.00,1012.50, 11.400,
1 .720, 906.00, 152.00,   6.00, 278.00/
 DATA(DATAPT(253,I),I=1,10)/ 47.27,122.50,  122.00, 998.50, 10.600,
1 .720, 985.00, 161.00,   8.00, 328.00/
 DATA(DATAPT(254,I),I=1,10)/ 47.67,117.42,  718.00, 928.80,  8.500,
1 .600, 442.00, 115.00,  11.00, 145.00/
 DATA(DATAPT(255,I),I=1,10)/ 47.27,121.37, 1206.00, 873.40,  4.000,
1 .810,2313.00, 206.00,   7.00, 773.00/
 DATA(DATAPT(256,I),I=1,10)/ 48.38,124.73,   31.00,1009.50,  9.600,
1 .860,1973.00, 197.00,   5.00, 573.00/
 DATA(DATAPT(257,I),I=1,10)/ 46.08,118.30,  289.00, 978.80, 12.300,
1 .550, 407.00, 106.00,  11.00, 149.00/
 DATA(DATAPT(258,I),I=1,10)/ 46.62,120.50,  321.00, 974.80,  9.900,
1 .590, 203.00,  68.00,   7.00, 106.00/
 DATA(DATAPT(259,I),I=1,10)/ 18.48, 66.13,    4.00,1012.80, 25.900,
1 .740,1502.00, 200.00,  40.00, 383.00/
 DATA(DATAPT(260,I),I=1,10)/ 17.40, 83.93,    9.00,1012.20, 27.200,
1 .740,1311.00, 153.00,  40.00, 801.00/
 DATA(DATAPT(261,I),I=1,10)/ 37.77, 81.20,  763.00, 924.30, 10.500,
1 .740,1083.00, 164.00,  46.00, 233.00/
 DATA(DATAPT(262,I),I=1,10)/ 38.38, 81.67,  286.00, 979.20, 12.900,
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1 .700,1035.00, 149.00,  43.00, 344.00/
 DATA(DATAPT(263,I),I=1,10)/ 38.93, 79.88,  594.00, 943.20,  9.800,
1 .740,1098.00, 167.00,  44.00, 236.00/
 DATA(DATAPT(264,I),I=1,10)/ 38.40, 82.43,  252.00, 983.20, 12.900,
1 .720, 988.00, 140.00,  45.00, 235.00/
 DATA(DATAPT(265,I),I=1,10)/ 39.28, 81.55,  187.00, 990.90, 12.600,
1 .700, 976.00, 142.00,  44.00, 306.00/
 DATA(DATAPT(266,I),I=1,10)/ 44.53, 88.00,  208.00, 987.60,  6.500,
1 .700, 686.00, 121.00,  35.00, 230.00/
 DATA(DATAPT(267,I),I=1,10)/ 43.80, 91.07,  198.00, 989.20,  8.000,
1 .700, 739.00, 111.00,  41.00, 267.00/
 DATA(DATAPT(268,I),I=1,10)/ 43.07, 89.37,  262.00, 981.40,  7.200,
1 .700, 768.00, 117.00,  41.00, 278.00/
 DATA(DATAPT(269,I),I=1,10)/ 43.05, 87.93,  205.00, 988.30,  7.600,
1 .700, 738.00, 123.00,  36.00, 251.00/
 DATA(DATAPT(270,I),I=1,10)/ 42.83,106.33, 1627.00, 831.20,  7.400,
1 .530, 285.00,  92.00,  34.00, 142.00/
 DATA(DATAPT(271,I),I=1,10)/ 41.13,104.83, 1867.00, 807.50,  7.700,
1 .470, 372.00,  97.00,  50.00, 136.00/
 DATA(DATAPT(272,I),I=1,10)/ 42.82,108.73, 1696.00, 824.00,  6.900,
1 .500, 352.00,  72.00,  32.00, 175.00/
 DATA(DATAPT(273,I),I=1,10)/ 44.80,106.95, 1208.00, 874.60,  7.200,
1 .550, 410.00, 108.00,  35.00, 242.00/
 DATA(DATAPT(274,I),I=1,10)/ 38.67, 90.25,  163.00, 993.76, 13.300,
1 .690, 912.00, 109.00,  44.00, 231.00/
 DATA(DATAPT(275,I),I=1,10)/ 39.38, 74.45,   20.00,1010.83, 12.100,
1 .700,1155.00, 113.00,  26.00, 332.00/
 DATA(DATAPT(276,I),I=1,10)/ 47.08,122.57,   59.40,1006.10, 15.000,
1 .760, 886.50, 165.00,   4.60, 584.00/
 DATA(DATAPT(277,I),I=1,10)/ 39.47,123.75,  229.20, 985.80, 11.700,
1 .810, 965.20,  89.00,   2.00, 400.00/
 DATA(DATAPT(278,I),I=1,10)/ 37.80,122.47,  -25.60,1016.30, 15.000,
1 .760, 442.00,  68.00,   1.80, 320.00/
 DATA(DATAPT(279,I),I=1,10)/ 35.82,120.73,  173.40, 992.70, 15.300,
1 .640, 281.90,  46.00,   1.70, 250.00/
 DATA(DATAPT(280,I),I=1,10)/ 36.68,121.77,   40.80,1020.01, 12.500,
1 .770, 274.30,  59.00,   2.70, 291.00/
 DATA(DATAPT(281,I),I=1,10)/ 36.00,121.23,  292.60, 978.80, 15.300,
1 .640, 281.90,  50.00,   1.70, 270.00/
 DATA(DATAPT(282,I),I=1,10)/ 33.02,118.58,   41.10,1008.30, 14.700,
1 .790, 203.20,  42.00,   1.00, 190.00/
 DATA(DATAPT(283,I),I=1,10)/ 31.55,110.30, 1425.50, 856.70, 16.900,
1 .410, 345.40,  52.00,  58.90, 201.00/
 DATA(DATAPT(284,I),I=1,10)/ 33.47,111.97,  381.00, 969.50, 21.700,
1 .430, 193.00,  34.00,  26.00, 141.00/
 DATA(DATAPT(285,I),I=1,10)/ 32.87,114.40,  121.90, 999.10, 22.500,
1 .440,  88.90,  15.00,  10.00,  68.00/
 DATA(DATAPT(286,I),I=1,10)/ 35.28,116.62,  694.60, 934.10, 18.300,
1 .360,  63.50,  30.00,   2.80, 100.00/
 DATA(DATAPT(287,I),I=1,10)/ 37.83,121.28,  -22.30,1015.90, 15.800,
1 .640, 340.40,  58.00,   2.80, 287.00/
 DATA(DATAPT(288,I),I=1,10)/ 38.52,121.40,  -13.10,1014.80, 15.600,
1 .660, 429.30,  58.00,   5.40, 321.00/
 DATA(DATAPT(289,I),I=1,10)/ 40.27,120.15, 1139.30, 878.00, 10.300,
1 .530, 180.30,  77.00,  14.00, 210.00/
 DATA(DATAPT(290,I),I=1,10)/ 40.18,112.92, 1310.30, 865.70, 11.100,
1 .500, 160.00,  88.00,  16.70, 124.00/
 DATA(DATAPT(291,I),I=1,10)/ 38.75,104.78, 1758.70, 819.30,  9.400,
1 .540, 368.30,  86.00,  51.20, 203.00/
 DATA(DATAPT(292,I),I=1,10)/ 43.17,103.83, 1104.00, 886.60,  9.200,
1 .610, 426.70,  91.00,  44.00, 170.00/
 DATA(DATAPT(293,I),I=1,10)/ 39.05, 96.75,  294.10, 978.20, 12.200,
1 .690, 784.90,  96.00,  55.30, 350.00/
 DATA(DATAPT(294,I),I=1,10)/ 39.37, 94.90,  233.00, 988.90, 12.200,
```

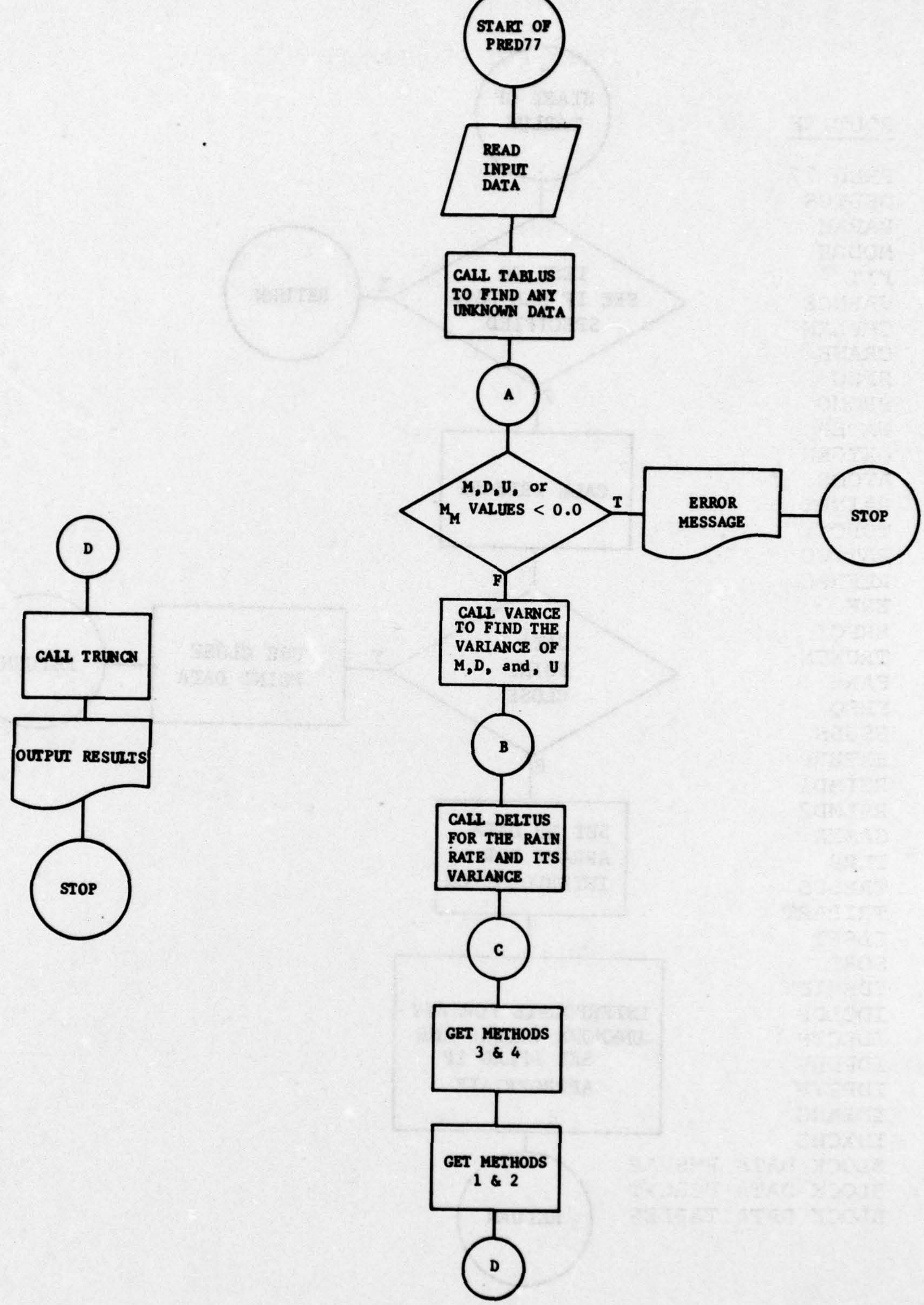
```
1 .710, 856.00,  99.00,  57.60, 282.00/
 DATA(DATAPT(295,I),I=1,10)/ 46.08, 94.35,  322.80, 974.00,  5.600,
1 .710, 688.30, 109.00,  33.20, 250.00/
 DATA(DATAPT(296,I),I=1,10)/ 37.73, 92.13,  317.60, 975.60, 13.100,
1 .690,1010.90, 110.00,  58.70, 350.00/
 DATA(DATAPT(297,I),I=1,10)/ 41.07, 96.33,  296.30, 977.80, 10.800,
1 .690, 706.10,  94.00,  47.80, 300.00/
 DATA(DATAPT(298,I),I=1,10)/ 34.63, 98.38,  336.20, 973.90, 16.400,
1 .640, 805.20,  74.00,  44.40, 274.00/
 DATA(DATAPT(299,I),I=1,10)/ 37.92, 85.97,  188.40, 990.80, 13.600,
1 .710,1130.30, 125.00,  46.00, 379.00/
 DATA(DATAPT(300,I),I=1,10)/ 44.05, 75.72,  178.30, 991.50,  7.200,
1 .750, 751.80, 165.00,  19.10, 290.00/
 DATA(DATAPT(301,I),I=1,10)/ 42.72, 76.88,  114.90, 999.30,  8.900,
1 .710,1013.50, 154.00,  29.30, 295.00/
 DATA(DATAPT(302,I),I=1,10)/ 42.22, 87.82,  180.40, 991.40,  9.400,
1 .720, 835.70, 125.00,  35.80, 291.00/
 DATA(DATAPT(303,I),I=1,10)/ 43.95, 90.73,  223.10, 986.20,  8.100,
1 .710, 749.30, 111.00,  44.10, 267.00/
 DATA(DATAPT(304,I),I=1,10)/ 34.67, 86.68,  167.30, 993.40, 16.100,
1 .690,1155.70, 122.00,  53.20, 375.00/
 DATA(DATAPT(305,I),I=1,10)/ 34.83, 92.30,  115.50, 999.50, 16.400,
1 .680,1277.60, 104.00,  56.70, 367.00/
 DATA(DATAPT(306,I),I=1,10)/ 36.67, 87.50,  227.80, 986.20, 14.200,
1 .710,1196.30, 116.00,  52.90, 350.00/
 DATA(DATAPT(307,I),I=1,10)/ 31.03, 93.18,   68.90,1005.10, 19.200,
1 .720,1328.40,  99.00,  61.60, 360.00/
 DATA(DATAPT(308,I),I=1,10)/ 31.07, 97.83,  285.30, 980.10, 20.000,
1 .630, 678.20,  75.00,  34.20, 330.00/
 DATA(DATAPT(309,I),I=1,10)/ 31.13, 97.72,  256.90, 983.30, 18.900,
1 .650, 698.50,  75.00,  39.10, 330.00/
 DATA(DATAPT(310,I),I=1,10)/ 29.43, 98.38,  186.50, 991.50, 20.600,
1 .660, 675.60,  80.00,  31.80, 400.00/
 DATA(DATAPT(311,I),I=1,10)/ 33.63, 95.45,  135.90, 997.20, 18.100,
1 .650, 934.70,  90.00,  49.40, 395.00/
 DATA(DATAPT(312,I),I=1,10)/ 31.27, 85.72,   53.60,1006.90, 19.200,
1 .720,1351.30, 113.00,  68.60, 395.00/
 DATA(DATAPT(313,I),I=1,10)/ 31.35, 85.75,   34.10,1009.20, 19.200,
1 .720,1351.30, 112.00,  68.60, 450.00/
 DATA(DATAPT(314,I),I=1,10)/ 30.53, 87.20,   -3.40,1013.70, 20.300,
1 .730,1358.90, 116.00,  60.30, 407.00/
 DATA(DATAPT(315,I),I=1,10)/ 32.35, 85.00,   31.70,1009.50, 18.600,
1 .720,1071.90, 112.00,  54.50, 336.00/
 DATA(DATAPT(316,I),I=1,10)/ 31.88, 81.57,  -26.50,1016.40, 18.900,
1 .740,1247.10, 112.00,  65.40, 511.00/
 DATA(DATAPT(317,I),I=1,10)/ 33.62, 84.33,  244.40, 984.50, 16.400,
1 .690,1234.40, 117.00,  50.00, 399.00/
 DATA(DATAPT(318,I),I=1,10)/ 33.92, 80.80,   33.80,1009.20, 18.100,
1 .680,1092.20, 111.00,  48.80, 425.00/
 DATA(DATAPT(319,I),I=1,10)/ 39.08, 76.75,    4.00,1012.80, 12.800,
1 .690,1117.60, 114.00,  26.50, 450.00/
 DATA(DATAPT(320,I),I=1,10)/ 39.47, 76.17,  -14.00,1014.90, 12.500,
1 .740,1013.50, 115.00,  30.50, 466.00/
 DATA(DATAPT(321,I),I=1,10)/ 39.38, 76.28,  -22.30,1016.00, 12.500,
1 .740,1013.50, 113.00,  30.50, 466.00/
 DATA(DATAPT(322,I),I=1,10)/ 35.13, 78.93,   31.10,1009.50, 16.100,
1 .700,1280.20, 113.00,  45.80, 360.00/
 DATA(DATAPT(323,I),I=1,10)/ 37.07, 77.95,   93.90,1002.00, 14.400,
1 .710,1137.90, 120.00,  38.60, 300.00/
 DATA(DATAPT(324,I),I=1,10)/ 37.13, 76.62,  -35.10,1017.50, 14.700,
1 .680,1087.10, 115.00,  35.40, 400.00/
 DATA(DATAPT(325,I),I=1,10)/ 38.72, 77.18,  -10.40,1014.50, 12.500,
1 .700, 929.60, 114.00,  30.60, 462.00/
 DATA(DATAPT(326,I),I=1,10)/ 37.30, 76.63,  -27.10,1016.50, 14.700,
```

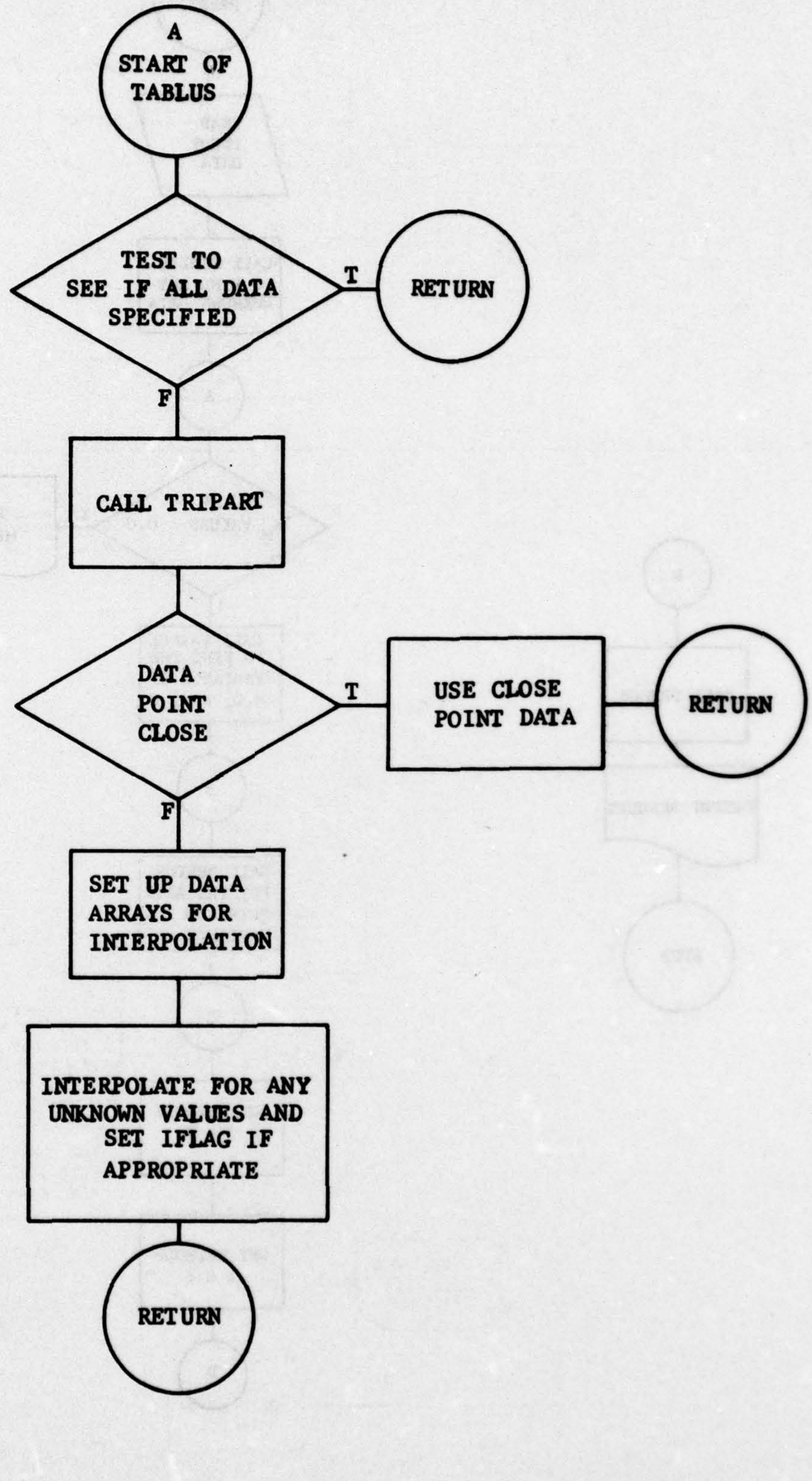
```
1 .680,1087.10, 114.00,  35.40, 479.00/
 DATA(DATAPT(327,I),I=1,10)/ 42.57, 71.60,   56.40,1006.30,  8.600,
1 .670, 937.30, 129.00,  22.50, 334.00/
 DATA(DATAPT(328,I),I=1,10)/ 40.70, 73.38,  -16.20,1015.20, 10.000,
1 .650,1242.10, 120.00,  31.00, 442.00/
 DATA(DATAPT(329,I),I=1,10)/ 40.43, 76.57,  112.20, 999.70, 11.900,
1 .650, 929.60, 130.00,  33.00, 471.00/
 DATA(DATAPT(330,I),I=1,10)/ 61.17,150.00,   26.00,1010.00,  1.800,
1 .710, 374.00, 113.00,   1.00, 150.00/
 DATA(DATAPT(331,I),I=1,10)/ 61.17,149.83,   35.00,1008.90,  1.700,
1 .710, 374.00, 113.00,   1.00, 138.00/
 DATA(DATAPT(332,I),I=1,10)/ 52.03,131.60,   34.00,1009.10,  7.600,
1 .770,2903.00, 224.00,   2.00, 886.00/
 DATA(DATAPT(333,I),I=1,10)/ 71.27,156.83,    9.00,1012.10,-12.600,
1 .790, 124.00,  75.00,    .25,  71.00/
 DATA(DATAPT(334,I),I=1,10)/ 70.12,143.67,   12.00,1011.70,-12.200,
1 .790, 179.00,  91.00,    .25, 125.00/
 DATA(DATAPT(335,I),I=1,10)/ 60.82,161.82,   38.00,1008.40, -1.800,
1 .790, 402.00, 135.00,   2.00, 148.00/
 DATA(DATAPT(336,I),I=1,10)/ 66.88,151.85,  196.00, 988.20, -5.900,
1 .670, 360.00, 103.00,   5.00, 150.00/
 DATA(DATAPT(337,I),I=1,10)/ 64.17,145.92,  386.00, 965.10, -2.500,
1 .710, 291.00,  93.00,   3.00, 157.00/
 DATA(DATAPT(338,I),I=1,10)/ 55.17,162.78,   29.00,1009.60,  3.300,
1 .860, 844.00, 211.00,    .25, 253.00/
 DATA(DATAPT(339,I),I=1,10)/ 64.83,147.83,  133.00, 996.30, -3.500,
1 .660, 285.00, 102.00,   5.00, 157.00/
 DATA(DATAPT(340,I),I=1,10)/ 62.25,145.50,  479.00, 953.80, -2.900,
1 .670, 282.00,  88.00,   5.00, 110.00/
 DATA(DATAPT(341,I),I=1,10)/ 59.67,151.62,   19.00,1010.90,  2.500,
1 .760, 586.00, 141.00,    .25, 218.00/
 DATA(DATAPT(342,I),I=1,10)/ 59.73,154.92,   40.00,1006.10,  -.100,
1 .750, 586.00, 137.00,    .25, 280.00/
 DATA(DATAPT(343,I),I=1,10)/ 58.33,134.33,    4.00,1012.80,  4.600,
1 .790,1389.00, 220.00,    .25, 387.00/
 DATA(DATAPT(344,I),I=1,10)/ 58.67,156.67,   15.00,1011.40,   .700,
1 .730, 502.00, 150.00,   1.00, 185.00/
 DATA(DATAPT(345,I),I=1,10)/ 57.82,152.50,    4.00,1012.80,  4.800,
1 .800,1440.00, 186.00,    .25, 332.00/
 DATA(DATAPT(346,I),I=1,10)/ 66.85,162.67,    3.00,1012.90, -6.200,
1 .770, 223.00, 108.00,    .25, 132.00/
 DATA(DATAPT(347,I),I=1,10)/ 62.97,155.67,  105.00, 999.90, -3.800,
1 .700, 425.00, 133.00,   7.00, 159.00/
 DATA(DATAPT(348,I),I=1,10)/ 64.50,165.50,    4.00,1012.70, -3.600,
1 .740, 418.00, 125.00,    .25, 199.00/
 DATA(DATAPT(349,I),I=1,10)/ 57.15,170.30,    7.00,1012.40,  1.400,
1 .900, 623.00, 205.00,    .25, 237.00/
 DATA(DATAPT(350,I),I=1,10)/ 52.75,174.08,   37.00,1008.60,  3.500,
1 .880, 716.00, 212.00,    .25, 221.00/
 DATA(DATAPT(351,I),I=1,10)/ 63.32,149.32,  731.00, 923.60, -3.600,
1 .720, 510.00, 138.00,   5.00, 171.00/
 DATA(DATAPT(352,I),I=1,10)/ 62.33,150.15,  105.00,1000.10,   .400,
1 .710, 727.00, 131.00,   4.00, 303.00/
 DATA(DATAPT(353,I),I=1,10)/ 63.87,160.83,    5.00,1012.60, -3.100,
1 .720, 360.00, 105.00,   2.00, 205.00/
 DATA(DATAPT(354,I),I=1,10)/ 61.12,146.28,    7.00,1012.40,  1.200,
1 .720,1506.00, 165.00,   2.00, 328.00/
 DATA(DATAPT(355,I),I=1,10)/ 59.48,139.82,    9.00,1012.10,  3.800,
1 .820, 824.00, 230.00,   2.00,1115.00/
 DATA(DATAPT(356,I),I=1,10)/ 19.70,155.07,    8.00,1012.30, 23.000,
1 .780,3393.00, 282.00,   9.00,1291.00/
 DATA(DATAPT(357,I),I=1,10)/ 21.32,157.83,    2.00,1013.00, 24.800,
1 .690, 582.00, 102.00,   8.00, 528.00/
 DATA(DATAPT(358,I),I=1,10)/ 20.93,156.48,   15.00,1011.50, 24.000,
```

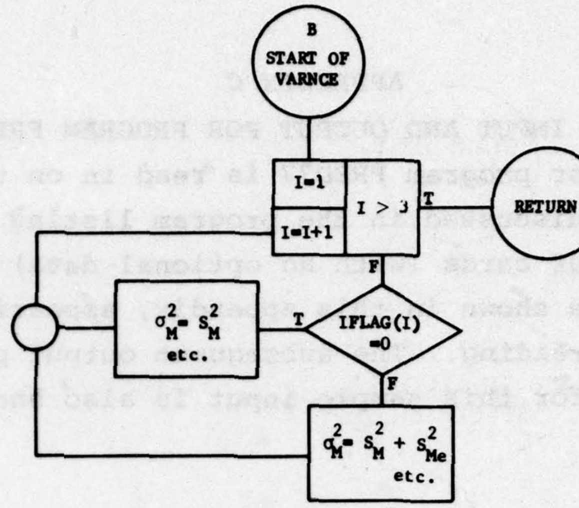
```
1 .740, 468.00,  95.00,    5.00, 347.00/
 DATA(DATAPT(359,I),I=1,10)/ 21.98,159.38,   31.00,1009.60, 23.900,
1 .760,1122.00, 201.00,    9.00, 582.00/
 END
```

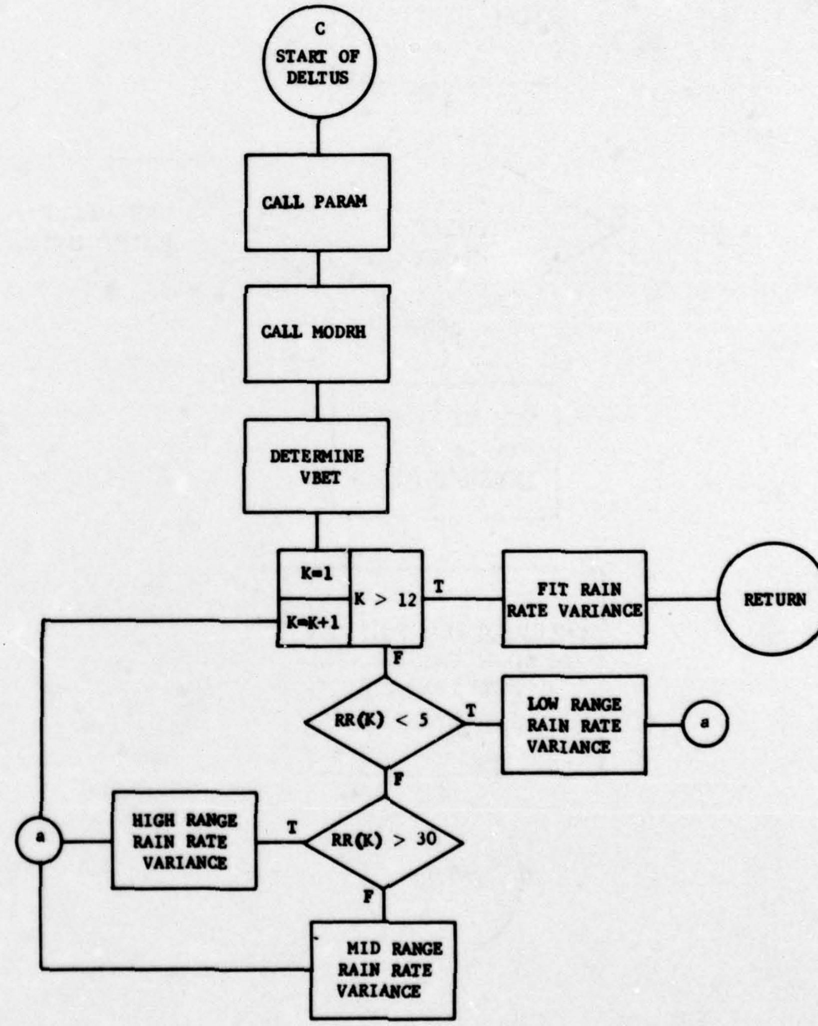
INDEX FOR PROGRAM PRED77

APPENDIX B. FLOW DIAGRAM OF PROGRAM PRED77




A
START OF
TABLUS
TEST TO
SEE IF ALL DATA
SPECIFIED
T
RETURN
F
CALL TRIPART
DATA
POINT
CLOSE
T
USE CLOSE
POINT DATA
RETURN
F
SET UP DATA
ARRAYS FOR
INTERPOLATION
INTERPOLATE FOR ANY
UNKNOWN VALUES AND
SET IFLAG IF
APPROPRIATE
RETURN

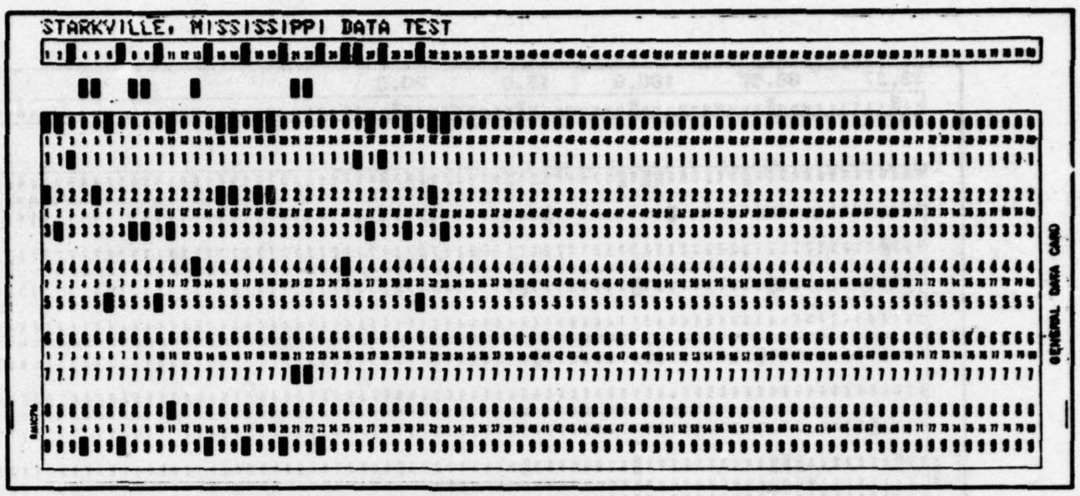

B
START OF
VARNCE
I=1
I=I+1
I > 3
T
RETURN
F
IFLAG(I)
=0
T
$\sigma_M^2 = S_M^2$
etc.
F
$\sigma_M^2 = S_M^2 + S_{Me}^2$
etc.


C
START OF
DELTUS
CALL PARAM
CALL MODRH
DETERMINE
VBET
K=1
K=K+1
K > 12
T
FIT RAIN
RATE VARIANCE
RETURN
F
RR(K) < 5
T
LOW RANGE
RAIN RATE
VARIANCE
a
F
HIGH RANGE
RAIN RATE
VARIANCE
T
RR(K) > 30
a
F
MID RANGE
RAIN RATE
VARIANCE

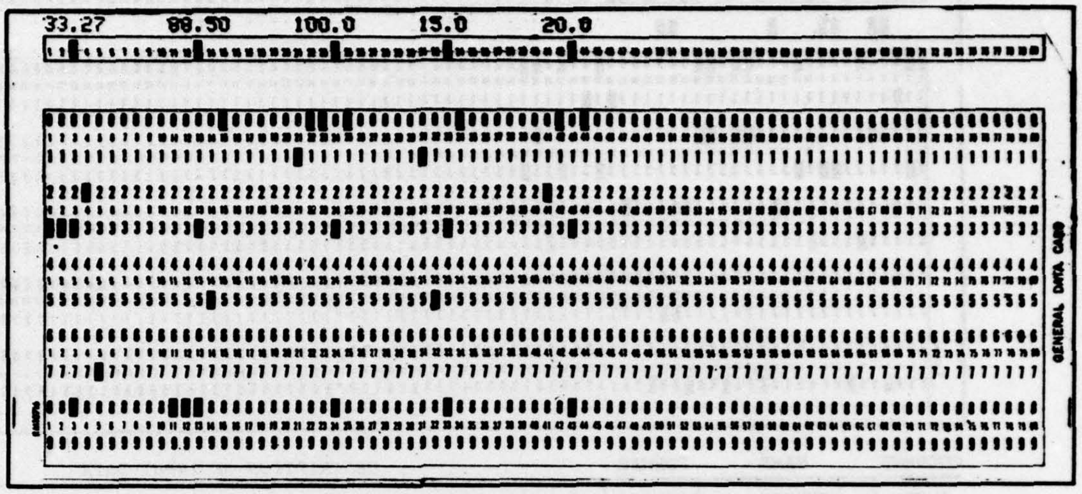
APPENDIX C

SAMPLE INPUT AND OUTPUT FOR PROGRAM FRED77

The data for program PRED77 is read in on three separate data cards, as discussed in the program listing in Appendix A. Sample data input cards (with no optional data) for Starkville, Mississippi, are shown in this appendix, appearing in the order of their reading. The subsequent output printout from program PRED77 for this sample input is also shown.

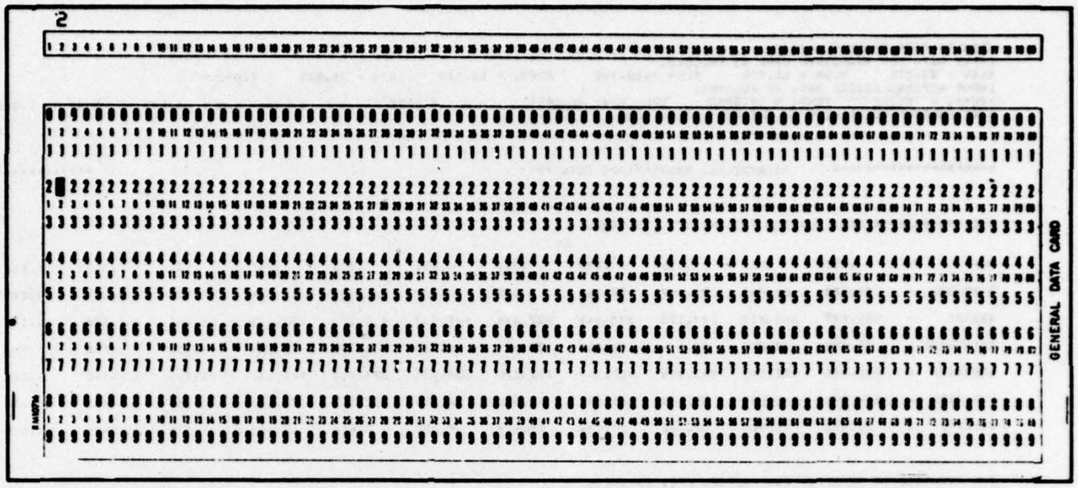


COLUMNS	NAME	FORMAT	DESCRIPTION OF INPUT DATA
1-80	STATID	8A10	Station identification



COLUMNS	NAME	FORMAT	DESCRIPTION OF INPUT DATA
1-10	XLAT	F10.x	Latitude of desired location (DD.MM)
11-20	XLON	F10.x	Longitude of desired location (DD.MM)
21-30	ELEV	F10.x	Elevation of desired location in meters
31-40	F	F10.x	Carrier frequency in GHz
41-50	DIS	F10.x	Distance along transmission path in km.

USCOMM - ERL



COLUMNS	NAME	FORMAT	DESCRIPTION OF INPUT DATA
1-2	*IZONE*	*I2*	*Numerical zone identifier (Figure 1)*
11-20	*P*	*F10.x*	*Mean surface pressure in millibars**
21-30	*RH*	*F10.x*	*Mean surface relative humidity, decimal fraction**
31-40	*T*	*F10.x*	*Mean surface temperature in Celsius**
41-50	*M*	*F10.x*	*Mean annual precipitation in millimeters**
51-60	*D*	*F10.x*	*Mean annual precipitation days**
61-70	*U*	*F10.x*	*Mean annual thunderstorm days**
71-80	*EMAX*	*F10.x*	*Greatest 30-yr monthly precipitation (mm)**

**Specification of these data is optional (see Section 5).*

RESULTS FROM PROGRAM PRED77.
INPUT DATA FOR MICROWAVE LINK AS FOLLOWS.
XLAT = 33.270 XLON = 88.500 ELEV =100.000 FREQ. = 15.000 DIS = 20.000 IZONE = 2
INPUT METEOROLOGICAL DATA AS FOLLOWS.
PRESS. = 0.000 TEMP. = 0.0000 REL. HUM. =0.0000 H = 0.0000 D = 0.000 U = 0.000 EMAX = 0.000
INTERPOLATED POINT LIES IN THE CONT. U.S. ZONE.

******************** STARKVILLE, MISSISSIPPI DATA TEST ********************

THE PROBABILITY MODIFICATION FACTOR, PT1, IS USED.

PCT	=	.010	.015	.020	.030	.050	.080	.100	.200	.500	.800	1.000
R(MM/HR)	=	93.469	80.245	70.862	57.640	41.042	26.837	21.697	12.744	6.516	4.359	3.061
VAR(R)	=	850.687	641.012	517.173	373.588	237.074	147.593	115.176	47.009	8.946	2.520	1.144
ATTEN(DB)	=	78.299	67.356	60.414	49.007	39.629	30.383	26.329	15.289	8.318	5.738	4.733
VAR(ATT)	=	892.286	687.150	561.879	416.945	330.374	282.758	253.514	101.131	21.793	7.550	4.600
ATT.(95)	=	127.496	111.135	99.466	83.467	69.656	58.334	52.905	32.152	16.003	10.203	8.060
ATT.(5)	=	30.332	25.950	22.560	17.534	11.948	7.159	5.616	3.088	1.920	1.631	1.575

THE PROBABILITY MODIFICATION FACTOR, PT2, IS USED.

PCT	=	.010	.015	.020	.030	.050	.080	.100	.200	.500	.800	1.000
R(MM/HR)	=	93.469	80.245	70.862	57.640	41.042	26.837	21.697	12.744	6.516	4.059	3.061
VAR(R)	=	850.687	641.012	517.173	373.596	237.074	147.593	115.176	47.009	8.946	2.520	1.144
ATTEN(DB)	=	99.187	87.086	78.299	67.956	51.028	33.376	26.329	15.249	8.318	5.738	4.733
VAR(ATT)	=	1431.081	1128.464	943.763	776.176	565.075	341.206	253.514	101.131	21.793	7.550	4.600
ATT.(95)	=	161.509	142.419	128.911	113.882	91.097	64.080	52.905	32.152	16.083	10.203	8.063
ATT.(5)	=	38.425	33.255	29.238	23.923	15.626	7.864	5.616	3.038	1.920	1.631	1.575

THE METHOD OF BARSIS ET AL. (1973) IS USED.

PCT	=	.010	.015	.020	.030	.050	.080	.100	.200	.500	.800	1.000
R(MM/HR)	=	93.469	80.245	70.862	57.640	41.042	26.837	21.697	12.744	6.516	4.059	3.061
VAR(R)	=	850.687	641.012	517.173	373.588	237.074	147.593	115.176	47.009	8.946	2.520	1.144
ATTEN(DB)	=	55.771	49.212	44.344	37.153	27.515	19.524	17.282	12.044	5.933	3.327	2.356
VAR(ATT)	=	452.706	360.357	302.707	231.993	159.263	116.758	109.228	62.760	11.088	2.538	1.013
ATT.(95)	=	95.814	80.480	73.007	62.262	48.363	37.485	34.727	25.328	11.472	5.962	4.016
ATT.(5)	=	21.605	18.792	16.559	13.079	8.295	4.630	3.686	2.370	1.375	.945	.784

THE METHOD OF BATTESTI ET AL. (1971) IS USED.

PCT	=	.010	.015	.020	.030	.050	.080	.100	.200	.500	.800	1.000
R(MM/HR)	=	93.469	80.245	70.862	57.640	41.042	26.837	21.697	12.744	6.516	4.059	3.061
VAR(R)	=	850.667	641.012	517.173	373.588	237.074	147.593	115.176	47.339	8.946	2.520	1.144
ATTEN(DB)	=	94.365	79.719	69.691	56.037	39.522	25.798	21.085	11.272	5.324	3.189	2.356
VAR(ATT)	=	1296.048	945.622	747.662	527.766	328.588	203.965	162.505	54.966	8.926	2.332	1.613
ATT.(95)	=	153.658	130.371	114.739	93.906	69.467	49.532	42.360	23.703	10.293	5.715	4.016
ATT.(5)	=	36.557	30.442	26.024	19.727	11.915	6.079	4.497	2.218	1.234	.906	.784