UM-36

PROCESSING AND ANALYSIS OF RAINFALL DATA

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ABSTRACT

Processing and analysis of rainfall data constitute an important component of hydrological analysis. The advent of computers, new techniques of hydrological analysis and special hydrological problems have placed new demands on hydrometeorological analysis.

Preliminary processing of rainfall data is essential before it is put to further use. The essential features of processing and analysis of rainfall data include storage of data on computer compatible devices, quality control, data conversion and further analysis.

In this User's manual appropriate procedures for carrying out the various component processes of the system are described keeping in view the data collection and storage of rainfall data in India. Nine Computer programmes for handling the various jobs at processing and analysis of rainfall data are described together with the input and output specifications and sample input and output data.

These programmes are developed in FORTRAN-IV language and are implemented on the VAX-11/780 computer system available with the National Institute of Hydrology, Roorkee. All these programmes could be run on other computers including the microcomputers having the FORTRAN compiler after suitable modifications as per the software requirements of the system. These computer programmes are very useful to hydrometeologists and hydrologists involved in hydrological analysis and design.

1.0 INTRODUCTION

In water resources planning and management it is imperative to know how much water is available and how best to use this water and the related land resources. Long and continuous historical records are required for system planning. Where the length of record of stream flow data is limited, the series are made up either by synthetic data generation technique or establishing rainfall-runoff relationships for extending the runoff series.

Hydrometeorological analysis forms an important and integral part of hydrological research. The hydrometeorological analysis comprises of a wide range of studies for providing input for water resources estimation and feasibility studies for developmental projects and estimation of design storm for determining design flood for hydraulic structures. One of the important parameters needed in these analysis is the rainfall which in itself forms part of the hydrologic cycle.

Rainfall data is collected at a number of locations in India. In earlier times, processing was generally done manually. The need for use of faster methods of processing the data has been felt with increase in the number of data records for processing and this led to the use of computers and data handling by punched cards. Primary processing of rainfall data is essential before further use can be made of this data in other analysis such as estimation of probable maximum precipitation using statistical and physical methods, mean areal precipitation estimation etc. Besides observational and instrumental errors, during the transfer of data from manuscript to punched cards, errors can occur at the stage of recording and punching. Detailed quality control of large volumes of data by visual inspection is quite impracticable. However, the use of digital computers has made the task simpler and all the data can be subjected to desired quality control checks. The transfer of data from punched cards on to magnetic tapes has made it possible to conveniently use the hydrometeorological data particularly rainfall for research and enquiry purposes.

2.0 PURPOSE AND CAPABILITIES

Rainfall data in its raw form would contain many gaps and inconsistent values. Preliminary processing of data is, therefore, essential before the data are subjected to further analysis. Processing of the data has two objectives. One is to evaluate the data for its accuracy and the other is to prepare the data in a form appropriate for subsequent analysis. Manual processing has obvious limitations. Computerised processing has several advantages over the manual processing.

In this user's manual the computerised methods of processing and analysis of rainfall data are described with a view to make the user self sufficient and self dependent in the processing and analysis of rainfall data and the use of the computer programs provided herein for the purpose of processing and analysis of rainfall data.

The methods of processing rainfall data described are simple to adopt and easy to use with microcomputers. For the analysis of rainfall data by the computer the most commonly used methods of estimating mean areal rainfall over a catchment are described. The methodology is explained with examples and illustrations where necessary.

This manual provides computer programmes which are meant for processing and analysis of rainfall data received from the India Meteorological Department (IMD). Different computer programmes, their descriptions, input specifications and test input & output are given in the Appendices.

3.0 METHODOLOGY

Before describing the methodology used for the processing and analysis of rainfall data, some of the important vocabulary frequently referred to in the text are explained below.

Average Depth of Rainfall:

The net rain after the application of the areal reduction factors (weightage factors by either **Thiessen** Polygon method or Isohyetal method) to the rain incident at different stations in any catchment.

Isohyetal:

A line drawn on a map passing through places having equal amounts of rainfall recorded during the same period at these places.

Mass Curve:

A graph showing the accumulated rainfall against time. If both the axes are accumulated rainfall, the curve obtained thus is known as double mass curve.

Thiessen Polygon:

The points of location of raingauges on a map are joined by straight lines and their perpendicular bisectors are drawn. The polygon formed around each raingauge station by these perpendicular bisectors is called Thiessen Polygon.

3.1 Storage of Rainfall Data

In India the rainfall data collected by state organisations is generally stored only in the form of printed records. The data are, however, transferred on to magnetic tapes by the office of the Additional Director General of Meteorology, IMD, Poona.

3.1.1 Format of daily rainfall data

The daily rainfall data were punched in a 31 card format as shown in figure 1(a) until 1970 and was switched over to a 24 card format as shown in figure 1 (b) since 1971.

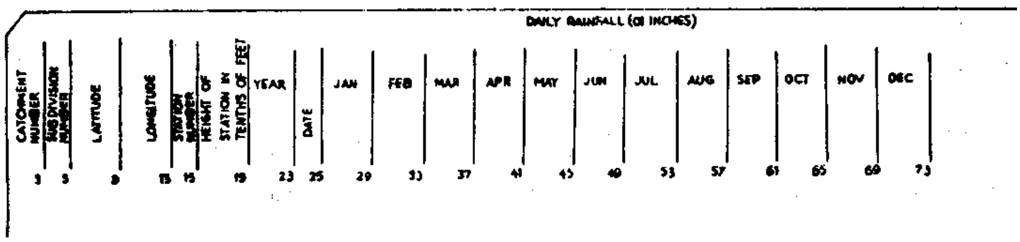


Figure 1(a)- 31 Card Daily Rainfall Data Format

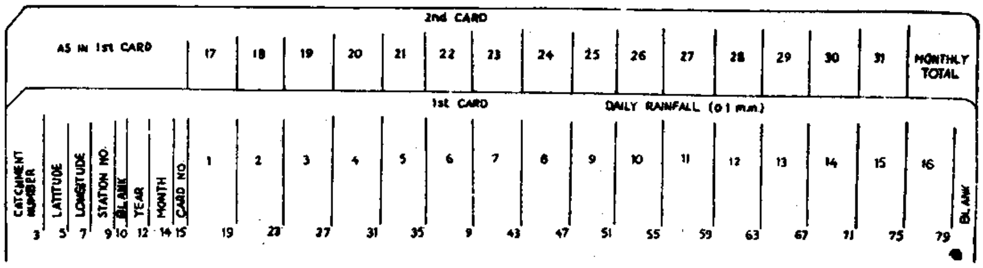


Figure 1(b)-24 card Daily Rainfall Data Format

In the 31 card format, the data of 12 months for each day are punched on each card together with station related information, year and date. In the 24 card format, each month's rainfall data are punched on 2 cards, 16 days data on the first card and 15 days data and monthly total on the second card.

3.2 Identification of Missing Rainfall Data

While retrieving the data for climatological purposes or inputing the data in real time, one often comes across missing data situations. Since blank in a data set is read as zero, necessary software for identifying the blanks and marking them appropriately has been developed. The computer programme TAPE.FOR is given in Appendix I. The programme reads the daily rainfall data of different stations from the input disk file of rainfall data supplied by IMD on magnetic tapes. The blank spaces in the data are read and replaced by-999 while rewriting the whole data onto another disk file.

3.3 Estimation of Missing Rainfall Data

Data for the period of missing rainfall data could be filled using estimation technique. The length of period upto which the data could be filled is dependent on individual judgement. Rainfall for the missing period is estimated either by using the normal ratio method or the distance power method.

3.3.1 Normal ratio method

In the normal ratio method, the rainfall R_A at station A is estimated as a function of the normal monthly or annual rainfall of the station under question and those of neighbouring stations using actual rainfall data recorded at neighbouring stations for the period of missing data at the station under question.

$$R_A = \frac{\sum_{i=1}^{n} \frac{NR_A}{NRi} \times R_i}{n} \qquad \ldots(1)$$

where,

R_A is the estimated rainfall at station A

R_i is the rainfall at surrounding stations

NR_A is the normal monthly or seasonal rainfall at station A.

NR_i is the normal monthly or seasonal rainfall at station i

n is the number of surrounding stations whose data are used for estimation.

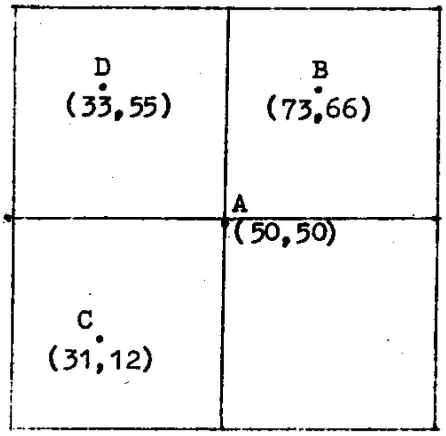
A computer programme GAPF.FOR for estimation of the missing data by the normal ratio method is described in Appendix II.

3.3.2 Distance power method

In this method, the rainfall at a station is estimated as a weighted average of observed rainfall at the neighbouring stations. The weights are taken as equal to the reciprocal of the distance or some power of distance of the estimator stations from the estimated stations:

$$R_A = \frac{\sum_{i=1}^{n} \frac{R_i}{D_i^2}}{\sum_{i=1}^{n} \frac{1}{D_i^2}} \qquad ...(2)$$

where, R_A and R_i has the same notation as in equation (1) and D_i is the distance of estimator station from the estimated station. The procedure for estimating rainfall data by this technique is indicated.



If A,B,C and D are the locations of stations, the distance of each estimator station (B,C, and D) from the station (A) whose data is to be estimated is computed with the help of the coordinates using the formula

$$D_i = [(x-x_i)^2 + (y-y_i)^2]^{1/2} \qquad \ldots(3)$$

where x and y are the coordinates of the station whose data is estimated and x_i and y_i are the coordinates of the estimator stations. The weights $1/D_i^2$ are computed for each station and the rainfall at station A is estimated using the equation (2). The computer programme for the procedure is described in Appendix III.

3.4 Adjustment of Data

To obtain homogenity among and within measurements of rainfall data, adjustment of the data becomes necessary. The 'Double Mass Curve' is used to check the consistency of the rainfall data of a particular period. Double mass analysis is a graphical method for identifying and adjusting inconsistencies. This is carried out by comparing the data of the station with the general trend of the reference stations in the neighbourhood. As the name implies the double mass curve's both axis are accumulated rainfall. Cumulated rainfall data of the station whose data is to be checked is plotted against the average cumulated rainfall data at a number of nearby stations. Usually the accumulated seasonal or annual rainfall values of reference station or stations is taken as abscissa and those of the station under question as ordinate (figure 2).

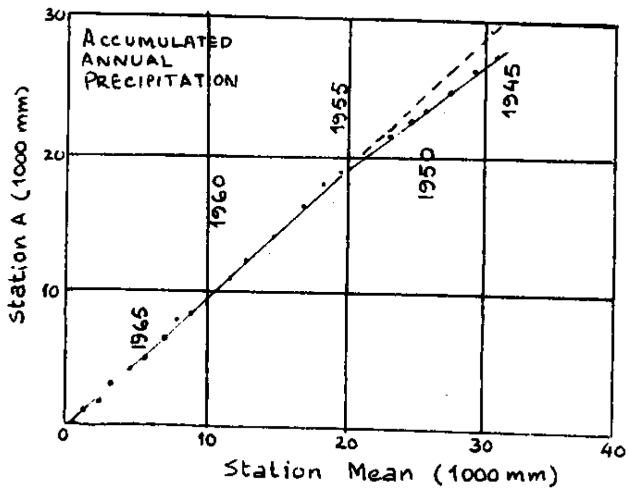


Figure 2: Double Mass Curve

Divergence of the line from a straight line indicates an error at the gauge under testing. The period of the error is known by identifying the point at which the slope of the line changes. A computer programme DOUBLE.FOR is given in Appendix IV which handles the computational aspects of double mass analysis.

3.5 Cumulated Rainfall Totals

In hydrological analysis cumulated rainfall totals for different periods such as 10 daily, monthly and seasonal are required for use in the developing of rainfall runoff relationships and the determination of water availability. With this in view a computer program is prepared which computes the ten daily, monthly, seasonal and annual rainfall amounts. The details of the computer programme TENDAY.FOR are given in Appendix V.

3.6 Determination of Maximum Rainfall for Different Durations

For the purpose of the determination of design flood for planning the construction of medium and large dams the design storm is used. Rainstorm analysis is the first step in the design storm estimation procedure. For arriving at dependable estimates of design storm depths, it is necessary to make a judicious selection of the pertinent storms over the catchment. A list of all rain periods when the maximum rainfall amounts were received is made. With the help of computer it is easy to make a print out of the maximum 1 day, 2 days, 3 days, 4 days and 5 days rainfall amounts for major storms in the vicinity of the catchment.

In Appendix VI a computer programme MAX.FOR for the estimation of maximum rainfall for different durations (1,2,3,4 and 5 days) is given together with relevant details.

3.7 Estimation of Mean Areal Rainfall

Precipitation observations from gauges are point measurements and as is characteristic of the precipitation process, exhibit appreciable spatial variation over relatively short distance. An accurate assessment of areal rainfall is a necessary pre-requisite and basic input to the hydrological models. It is also well recognized that the catchment rainfall derived from sparsely gauged areas can only be regarded as an index of rainfall and even with an ideal gauge coverage the catch from gauges itself cannot be regarded as true due to wind influence and orographic characteristics.

Numerous methods of calculating areal rainfall from point raingauge measurements have been proposed. The choice of the method is dependent on:

i) quality and nature of data

ii) importance of use and required precision

iii) availability of time and

iv) availability of computer.

The most commonly used methods are:

a) arithmetic average

b) Thiessen polygon method

d) isohyetal method

3.7.1 Arithmetic average

The simplest technique for developing the average depth over an area is arithmetic average of the values at gauges within the area for the time period of concern. If the gauges are relatively uniformly distributed over the catchment and the values are not greatly different from the average value, this technique will yield reliable results.

3.7.2 Thiessen polygon

The Thiessen Polygon method is used with non-uniform stations spacing and gives weights to stations data according to the area which is closer to that station than to any other station. This area is found by drawing the perpendicular of the lines joining the nearby stations so that polygons are formed around stations. The polygons thus formed around each station are the boundaries of the effective area assumed to be controlled by the station. The area governed by each station is planimetered and expressed as a percentage of total area. Weighted average rainfall for the basin is computed by multiplying each station precipitation amount by its assigned percentage of area and totalling.

The weighted rainfall is given by

$$\bar{P} = \frac{\sum_{i=1}^{n} P_i W_i}{\sum_{i=1}^{n} W_i} \qquad \ldots(4)$$

where, $\bar{P}$ is the average catchment precipitation, P_i is the precipitation at station 1 to n, W_i the respective weights.

If a few observations are missing it is better to estimate the missing data than to construct new set of polygons.

The computation of mean areal precipitation using Thiessen weights is given in Appendix VII.

The advantage of this method is stations outside the catchment may also be used for assigning weights of marginal stations within the catchment. The disadvantage, however, is it assumes that precipitation between two stations varies linearly and does not make allowance for variation due to orography.

3.7.3 Isohyetal method

The isohyetal method employs the area encompassed between isohyetal lines. Rainfall values are plotted at their respective stations on a suitable base map and lines of equal rainfall, called isohyets are drawn. In regions of little or no physiographic influence, the drawing of isohyetal contours is a relatively simple matter of interpolation in which the degree of smoothness of contours and of profiles which may be drawn or inferred from their spacing, is consistent with the spacing of stations, and the quality and variability of the data.

In regions of pronounced orography, where the precipitation is influenced by topography, the analyst should take into consideration, the orographic effects, storm orientation, etc. to adjust or interpolate between station values.

The modern computers equipped with plotters have the ability to draw isohyetal maps. Analysts, however, prefer to carry out the analysis manually after getting the values plotted on the maps.

The average depth of precipitation is computed by measuring the area between successive isohyets and determining the total volume and dividing by total area.

The average depth is given by the relation:

$$\bar{P} = \frac{\sum_{i=1}^{n} P_i \, A_i}{\sum_{i=1}^{n} A_i} \qquad \ldots(5)$$

where, A_i is the area between successive isohyets $\bar{P}$ and P_i have the same notation as in Equation 4.

The computation of the mean areal precipitation by isohyetal method is given in appendix VIII.

3.8 Distribution of Daily Rainfall Data into Hourly Rainfall

For hydrological analysis, rainfall data of shorter duration is required. The net work of recording raingauges in India being small in comparison to that of daily (non-recording) raingauge, it becomes necessary to convert the daily rainfall into shorter period intervals either manually or by using appropriate computer routines. The information of short interval rainfall is used together with information of daily rainfall from nearby non-recording (daily) gauges.

Mass curve is a graphical display of accumulated rainfall vs time. Mass curves of accumulated rainfall at (non-recording) daily stations and recording stations are prepared by plotting the accumulated rainfall values against time for the storm duration under analysis.

A comparison of the mass curves of the recording raingauge stations with those of the non-recording stations would help in deciding which recording raingauges or group of gauges could be considered as representative of which of the non-recording raingauge for the purpose of distributing daily rainfall into hourly rainfall.

The procedure for distribution of daily rainfall at non-recording raingauge stations into hourly rainfall is explained together with a computer programme in Appendix IX

4.0 RECOMMENDATIONS

The programs described in Appendix I and V need large storage space and may not be possible to be used with micro computers which do not have the facility of tape drives or disk drives. However, they can be used if the data are transferred onto floppy disks prior to the use of these programs.

The other programs of processing and analysis described need only small storage space and as such are suitable for use on micro-computers.

REFERENCES

1 National Institute of Hydrology, (1984-85), 'Processing of Precipitation Data', Manual M-2.

2. Ramasastri, K.S. and S.M.Seth, 'Normal Ratio and Distance Power Method for Estimation of Missing Rainfall Data-A Case Study', Hydrology, Jour. of Assoc. of Hydrologists Vol.VIII, No.1, pp.94-100.

3. Ramasastri, K.S., Pratap Singh, and S.M.Seth, (1985), 'Computerised Processing and Analysis of Precipitation Data', Hydrology, Journal of Indian Assoc. of Hydrologists, Vol.VIII, No.3, pp.1-10.

4. World Meteorological Organisation, (1970),'Guide to Hydrometeorological Practices'.

APPENDIX I

A. COMPUTER PROGRAMME TAPE.FOR

```
C       PROGRAMME TO READ DATA FROM IMD TAPES AND OTHER SOURCE
C       IT WILL CHECK MISSING DATA AND SUBSTITUTE THEM BY -999
C       CONDITIONS! IT WILL NOT TAKE CARE OF CONTINUOUS YEAR DATA
C                   !THEREFOR,FOR WATERYEAR CALCULATIONS NOT APPLICABLE

        DIMENSION IR(12,31),NDAY(12),SUMMON(100,13)
        CHARACTER*10 ANSTAT
        CHARACTER*16 ANDIST,ANSTN
        DATA NDAY/31,28,31,30,31,30,31,31,30,31,30,31/
        OPEN(UNIT=1, FILE= 'WORK.DAT', STATUS ='OLD')
        OPEN(UNIT=2, FILE= 'WORK9.DAT', STATUS ='NEW')
        GO TO 777
888     BACKSPACE(UNIT=1)
777     READ(1,109)NOSTAT,NODIST,ANSTAT,ANDIST,ANSTN
        WRITE(2,110)NOSTAT,NODIST,ANSTAT,ANDIST,ANSTN
109     FORMAT(2I2,A,2A/)
110     FORMAT(1X,2I2,A,2A/)
        NYR=1000
        DO 40 II=1,NYR
        DO 10 I=1,12
        READ(1,101,ERR=111,END=999)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,
        2(IR(I,J),J=1,15)
        IF(LAT.EQ.'  ')GO TO 111
C       IF((IR(I,2)-1900).GT.0)GO TO 111
        DO 600 J=1,15
        IF(IR(I,J).EQ.'    ') IR(I,J)='-999'
600     CONTINUE
        WRITE(2,201)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,
        2(IR(I,J),J=1,15)
        IYEAR=IYEAR+1900
        IF(I.EQ.2) CALL LEAPYR(IYEAR,NDAY)
        READ(1,101)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,(I
        1R(I,J),J=16,NDAY(I))
        DO 601 J=16,NDAY(I)
        IF(IR(I,J).EQ.'    ') IR(I,J)='-999'
601     CONTINUE
        WRITE(2,201)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,(IR(I,J), J=16,
        1NDAY(I))
10      CONTINUE
        GO TO 40
111     BACKSPACE (UNIT=1)
        DO 50 K=1,31
        READ(1,105,ERR=888,END=999)ICATNO,STR,LAT,LONG,ISTANO,IYEAR,IDATE,
        1(IR(J,K), J=1,12)
        DO 603 J=1,12
        IF(K.GT.NDAY(J)) GO TO 603
        IF(IR(J,K).EQ.'    ') IR(J,K)='-999'
603     CONTINUE
```

```
      WRITE(2,205)ICNTRD,LAT,LONG,ISTAND,IYEAR,IMNTE,(IR(J,
     1K), J=1,12)
   50 CONTINUE
   40 CONTINUE
  101 FORMAT(I3,A2,2I2,2X,2I2,I1,16A4)
  201 FORMAT(1X,I3,A2,2I2,2X,2I2,I1,16A4)
  105 FORMAT(I3,A2,2I4,I2,4X,I4,I2,12A4)
  205 FORMAT(1X,I3,2X,2I4,I2,4X,I4,I2,12A4)
  999 STOP
      END
C
      SUBROUTINE LEAPYR (IYEAR,NDAY)
C     YEAR SHOULD BE DEFINED IN FULL DIGITS IN MAIN PROGRAMME
      DIMENSION NDAY(2)
      LPYR=MOD(IYEAR,4)
      IF(LPYR.EQ.0) NDAY(2)=29
      RETURN
```

B. DESCRIPTION OF COMPUTER PROGRAMME TAPE.FOR

The computer programme TAPE.FOR is written in FORTRAN IV language and run on VAX 11/780 digital computer system. The programme is meant to read daily rainfall data from IMD tapes and identify the missing data periods. The daily rainfall data is read from either the 24 card or 31 card format as written on the tape and then written back on to an output file replacing the missing data by -999. For identifying the leap years the programme uses a sub-routine LEAPYR. Some of the important variables used in the program are described below.

VARIABLE	DESCRIPTION
NDAY	Number of days in different calendar months.
NOSTAT	Code Number of State
NODIST	Code Number of District
AMSTAT	Name of the State in India
AMDIST	Name of the district in the state
AMSTN	Name of the station in the district
IR	Two dimensional array containing daily rainfall data of different raingauge stations.
IYEAR	Calendar year for which data is provided.

C. INPUT SPECIFICATIONS

The input data is the daily rainfall supplied by the India Meteorological Department either in 31 card or 24 card format. The data is supplied through an input

INPUT DATA FILE

```
1129M P      RAIPUR          MAINPUR         HYDRO  319201782141404721948
CAT.NO.PUNCHED AS 320 INSTEAD OF 319 FOR THE PERIOD 1960-70
320  2017821414    19600100000000000000000000004300003120000000000000000
320  2017821414    19600200000010000000000000003705620191000000000000000
320  2017821414    19600300000028000000000000003502190160007700000000000
320  2017821414    19600400000000000000000000000062003001060000000000000
320  2017821414    19600500000000000000000000000093001000700000000000000
320  2017821414    19600600000000000000000000000011004000720020000000000
320  2017821414    19600700000000000000000000000063002000000000000000000
320  2017821414    19600800000000000000000000008500890035010200000000000
320  2017821414    19600900000000000000000000008200010003000100000000000
320  2017821414    19601000000000000000000000000061000000600580000000000
320  2017821414    19601100000000000000000000009005700000000000000000000
320  2017821414    19601200000000000000000047000000280021000000000000000
320  2017821414    19601300000000000000000020009000201150000003000000000
320  2017821414    19601400000000000000000000000000180000000230000000000
320  2017821414    1960150000     00000000000000000370120000000000000000
320  2017821414    19601600000000000000000000830078001500000000000000000
320  2017821414    19601700000000000000000009600390086000000000000000000
320  2017821414    19601800000000000000000000010000000000000000000000000
320  2017821414    1960190000000000     000000450000004401610000000000000
320  2017821414    19602000000000000000000000000000100013000000000000000
320  2017821414    19602100000000000000000040030001180073008000000000000
320  2017821414    19602200000000000000000043000500370010015000000000000
320  2017821414    19602300000000000000000030004700610003014000000000000
320  2017821414    19602400000000000000000000000059000000850000000000000
320  2017821414    19602500000000000000000000011000000001910000000000000
320  2017821414    19602600000000000000000000210097000000220067000000000
320  2017821414    19602700000000000000000350018700580000000000000000000
320  2017821414    19602800000000000000000153000200080000000000000000000
320  2017821414    19602900000000000000000085002000800000050000000000000
320  2017821414    1960300000     000000000001000000100084000000000000000
320  2017821414    1960310055     0000     0000     01100000     0000     0000

1704ORISSA     CUTTACK          JAGATSINGPUR              320201686101400091971

32020168610600110000000000000000000000000000000000000000000000000000000
320201686106001200000000000000000000000000000000000000000000000005400700055
32020168610600210000000000000000000000000000000000000000000000000000000
32020168610600220000000000000000000000000000000000000000700000000000
32020168610600310000000000000000000000000000000000000000000000000000000
320201686106003200000000000000000000000000000000000000000000000000000000000
32020168610600410000000000000000000000000000000000000000000000000000000
32020168610600420000000000000000000000000000000000000000000000000000032
32020168610600510000009500000000000000000000000000065000000000000000000
320201686106005200000000000000000000300000000007400000000000400000000000000000
32020168610600610083000000430013000000150000000000000350243000000000500011
3202016861060062
32020168610600710002000000000000000780077014700220349047801920001000000000002
3202016861060072000001350000000600060011000900000000000000000570100007000020063
320201686106008100140006000800000012000000000051012100390025000000000620128
320201686106008200000034001500000000000000900000044000200000000000000000000000
320201686106009100000000007300020000005301460098001900040000000000090000000
320201686106009200000000000000000230000002300450000000000000000005200720008
3202016861060101003001340000000000190000018402350465000500640000000000000000
3202016861060102001400000221000000000000000000000000000000000000000000000000
32020168610601110000000000000000000000000000000000000000000000000000000
3202016861060112000000100217025100100000000000000000000000000000000000000
32020168610601210000000000000000000000000000000000000000000000000000000
320201686106012200000000000000000000000000000000000000000000000000000000000
```

file WORK.DAT. A copy of the sample input file is provided.

D. OUTPUT SPECIFICATIONS

The output file WORK9.DAT consists of a header followed by the daily rainfall data. The header consists of the code, State name, district name followed by the name of the raingauge station. Each data card contains the catchment code, latitude and longitude of the station, the year, month or date followed by rainfall data as specified below.

31 card format

REC No.	OUTPUT LIST	FORMAT	REMARKS
1.	ICATNO	1x,I3	
2.	LAT	2x,I4	
3.	LONG	I4	
4.	ISTANO	I2	
5.	IYEAR	4x, I4	
6.	IDATE	I2	
7.	(IR(J,K),J=1,12)	12 A4	Twelve months' daily rainfall data for each date.

24 card format

REC No	OUTPUT LIST	FORMAT	REMARKS
1.	ICATNO	1x,I3	
2.	LAT	A2,I2	
3.	LONG	I2	
4.	ISTANO	2x	

5.	IYEAR	I2	
6.	IMONTH	I2	
7.	ICRDNO	I1	
8.	(IR(I,J),J=1,15) or (IR(I,J),J=16,NDAY)	16 A4	Two cards per month. 15 days data in card 1 and 16 days data in card 2

A sample output for both the 31 card and 24 card format is enclosed. The rainfall data at Mainpur is in the 31 card format while that of Cuttack is in the 24 card format.

OUTPUT FILE

```
1129N P       RAIPUR          NAINPUR

320  2017821414    1960 100000000000000000000004300000312000000000000000
320  2017821414    1960 200000010000000000000003705620191000000000000000
320  2017821414    1960 300000028000000000000003502190160007700000000000
320  2017821414    1960 400000000000000000000000000620030010600000000000
320  2017821414    1960 500000000000000000000000000930010007000000000000
320  2017821414    1960 600000000000000000000000001100400072002000000000
320  2017821414    1960 700000000000000000000000006300200000000000000000
320  2017821414    1960 800000000000000000000008500890035010200000000000
320  2017821414    1960 900000000000000000000008200010003000100000000000
320  2017821414    19601000000000000000000000000061000000060058000000000
320  2017821414    19601100000000000000000000000090057000000000000000000
320  2017821414    19601200000000000000000047000000280021000000000000000
320  2017821414    19601300000000000000000020009000201150000003000000000
320  2017821414    19601400000000000000000000000000019000000002300000000
320  2017821414    196015000-999000000000000000003701200000000000000000
320  2017821414    19601600000000000000000000083007900150000000000000000
320  2017821414    19601700000000000000000000096003900840000000000000000
320  2017821414    19601800000000000000000000001000000000000000000000000
320  2017821414    196019000000000000-99900000004500000044016100000000000
320  2017821414    19602000000000000000000000000000100013000000000000000
320  2017821414    19602100000000000000000040030001120073009000000000000
320  2017821414    19602200000000000000000430005003700100150000000000000
320  2017821414    19602300000000000000000030004700610003014000000000000
320  2017821414    19602400000000000000000000000590000008500000000000000
320  2017821414    19602500000000000000000000011000000000191000000300000
320  2017821414    19602600000000000000000000210097000000220067000000000
320  2017821414    19602700000000000000000350018700580000000000000000000
320  2017821414    19602800000000000000000015300020008000000000000000000
320  2017821414    19602900000000000000000085002000300000005000000300000
320  2017821414    1960300000      00000000000100000010008600000000000000000
320  2017821414    1960310055      0000     0000     01100000     0005     3000

17 4ORISSA     CUTTACK          JAGATSINGPUR

320201686   60 1100000000000000000000000000000000000000000000000000000000
320201686   60 120000000000000000000000000000000000000000000000000005400700055
320201686   60 2100000000000000000000000000000000000000000000000000000000
320201686   60 220000000000000000000000000000000000000700000000000000-999
320201686   60 3100000000000000000000000000000000000000000000000000000000
320201686   60 3200000000000000000000000000000000000000000000000000000000000000
320201686   60 4100000000000000000000000000000000000000000000000000000000
320201686   60 4200000000000000000000000000000000000000000000000000000032
320201686   60 5100000095000000000000000000000000000000450000000000000000000
320201686   60 52000000000000000000030000000000740000000000040000000000000000000
320201686   60 6100830000004300130000001500000000000000350243000000000000500011
320201686   60 62-999-999-999-999-999-999-999-999-999-999-999-999-999-999-999
320201686   60 710002000000000000007800770147002203490678019200010000000000002
320201686   60 72000001350000000600060011000900000000000000000005701000070000020063
320201686   60 8100140006000800000012000000000051012100390025000000000000620129
```

APPENDIX-II

A. COMPUTER PROGRAMME GAPF.FOR

```
C       PROGRAME FOR ESTIMATING MISSING DATA USING NORMAL RATIO METH
        DIMENSION RN(100,50),RAIN(100,50),ARAIN(100,50)
        OPEN(UNIT=1,FILE='GAPF.DAT',STATUS='OLD')
        OPEN(UNIT=2,FILE='GAPF.OUT',STATUS='NEW')
        READ (1,*) NEV
        WRITE(2,51)
51      FORMAT(20X,'RAINFALL AT DIFFEREN STATIONS AFTER FILLING THE
        1 MISSING RECORDS')
        WRITE(2,52)
52      FORMAT(10X,120('-'))
        DO 1 I=1,NEV
        READ(1,*) NS
        READ(1,*) NRAIN
        READ(1,*)((RN(J,K),K=1,NRAIN),J=1,NS)
        READ(1,*)((RAIN(J,K),K=1,NRAIN),J=1,NS)
        DO 2 J=1,NS
        DO 3 K=1,NRAIN
        IF(RAIN(J,K).NE.-1)GO TO 100
        RAT=0.
        L=0
        DO 4 K1=1,NS
        IF(J.EQ.K1) GO TO 4
        IF(RAIN(K1,K).EQ.-1) GO TO 4
        L=L+1
        RAT=RAT+RAIN(K1,K)/RN(K1,K)
4       CONTINUE
        IF(L.EQ.0)ARAIN(J,K)=RN(J,K)
        IF(L.NE.0)ARAIN(J,K)=RAT*RN(J,K)/L
        GO TO 101
100     ARAIN(J,K)=RAIN(J,K)
101     CONTINUE
3       CONTINUE
2       CONTINUE
        WRITE(2,30)I
30      FORMAT(4X,'EVENT NO:-',I5)
        WRITE(2,45) ((ARAIN(J,K),K=1,NRAIN),J=1,NS)
45      FORMAT(4X,<NRAIN>F10.3)
1       CONTINUE
50      STOP
        END
```

B. DESCRIPTION OF COMPUTER PROGRAMME GAPF.FOR

The computer programme GAPF.FOR is written in FORTRAN IV language and run on VAX-11/780 digital computer system. The programme is used for estimating the missing station rainfall data using normal ratio method. The imertant variables used in the main programme are described below:

VARIABLE	DESCRIPTION
NS	No. of raingauge stations
NEV	No. of events
NRAIN	No. of rainfall values
RN	Two dimensional array containing the normal rainfall values at each raingauge stations
RAIN	Two dimensional array containing the observed rainfall values at each raingauge stations for different event
ARAIN	Two dimensional aray containing the observed rainfall values and estimated values of missing rainfall at each raingauge stations for different event

C. INPUT SPECIFICATIONS:

The input lists and their specifications which are to be supplied through an input file GAPF.DAT are:

REC No.	INPUT LISTS	FORMAT	REMARK
1.	NEV	FREE	
2.	NS	FREE	Repeat record no. 2 to 5 for each event
3.	NRAIN	FREE	

4.	((RN(J,K),K=1,NRAIN) J=1, NS)	FREE
5.	((RAIN(J,K),K=1,NRAIN), J=1, NS)	FREE

D. OUTPUT SPECIFICATIONS

The output file GAPF.OUT consists the values of the following output lists in thespecified format:

REC No.	OUTPUT LISTS	FORMAT	REMARK
1.	Nil	20X,'RAINFALL AT DIFFERENT STATIONS AFTER FILLING THE MISSING RECORD'	
2.	Nil	10X, 120 ('-')	Repeat record no. 3 and 4 for each event
3.	I	4 X, 'EVENT NO:-',I5	
4.	((ARAIN(J,K), K=1,NRAIN),J=1,NS)	4X, NRAIN F10.3	

E. EXAMPLE

The data below provide details of individual storm precipitation at four gauges A, B, C and D togather with normal annual precipitation. Estimate the missing storm precipitation data at station A using normal ratio method.

Gauge	A	B	C	D
Precipitation (mm)	-1	98.9	120.5	110.0
Normal annual (mm)	331.3	290.8	325.9	360.5

where -1 denotes the missing storm precipitation data at the respective station (station A).

(a) Input:

The input data, required to run the programme for estimating the missing precipitation data (station A in the above example), are supplied through the file GAPF.DAT. For the above example, the input file GAPF.DAT contains the following data:

```
1
4
1
331.3    290.8    325.9    360.5
 -1       98.9    120.5    110.0
```

(b) Output

```
RAINFALL AT DIFFERENT STATIONS AFTER FILLING THE
MISSING RECORDS

EVENT NO:-  1

112,087
 98,900
120,500
110,000
```

APPENDIX III

A. COMPUTER PROGRAMME DISPOW.FOR

```
C       PROGRAMME FOR INTERPOLATION OF RAINFALL BY DISTANCE POWER METHOD
        DIMENSION LAT(10),LONG(10),ST1(10),ST2(10),ST3(10),ST4(10),RF(10,20)
        DIMENSION DREC(10),WT(10),POW(10),DIST(10),ERF(20),DRF(20),STNCH(10,20)
        OPEN (UNIT = 1,STATUS = 'OLD',FILE = 'DIS.DAT')
        OPEN (UNIT = 2,STATUS = 'NEW',FILE = 'DIS.OUT')
        READ (1,*) NST,NVAL,NPOW
        READ(1,* ) (POW(I),I = 1,NPOW)
        DO 100 I = 1,NST
        READ (1,10) ST1(I),ST2(I),ST3(I),ST4(I),LAT(I),LONG(I)
        READ (1, *) (STNCH(I,J), J = 1,NVAL)
  100   READ (1, *) (RF(I,J), J = 1,NVAL)
        WRITE (2,1000) (ST1(I),ST2(I),ST3(I),ST4(I),I = 1,NST)
        NS = NST - 1
        DO 200 I = 1,NS
        DIS = (LAT(I+1)-LAT(1))**2+(LONG(I+1)-LONG(1))**2
        DIST(I) = 1.10 * SQRT(DIS)
200     WRITE(2,2000)(ST1(I+1),ST2(I+1),ST3(I+1),ST4(I+1)),ST1(1),ST2(1)
        1,ST3(1),ST4(1),DIST(I)
        DO 300 J = 1,NPOW
        TWT = 0.0
        DO 400 I = 1,NS
        DREC(I) = 1.0/DIST(I) **POW(J)
  400   TWT = TWT + DREC(I)
        DO 500 I = 1,NS
  500   WT(I) = DREC(I) / TWT
        DO 600 K = 1,NVAL
        ERF(K) = 0.0
        DO 600 I = 1,NS
        ERF(K) = ERF(K) + RF(I+1,K)*WT(I)*STNCH(1,K)/STNCH(I+1,K)
  600   DRF(K) = (RF(1,K) - ERF(K)) ** 2.0
        WRITE(2,4000) POW(J)
        WRITE(2,4000)(WT(I),I = 1,NS)
        WRITE(2,3000)(RF(1,K),K = 1,NVAL)
        WRITE(2,3000) (ERF(I),I = 1,NVAL)
        WRITE(2,5000) (DRF(I),I = 1,NVAL)
  300   CONTINUE
   10   FORMAT(4A4,2I4)
 1000   FORMAT(2X,'INTERPOLATED RAINFALL FOR'4A4'FROM'4(4A4))
 2000   FORMAT(2X,'DISTANCE OF '4A4'FROM'4A4'IS'F10.1'KMS')
 3000   FORMAT(2X,20F6.1)
 4000   FORMAT(2X,20F6.3)
 5000   FORMAT(2X,20F6.0)
        STOP
        END
```

B. DESCRIPTION OF COMPUTER PROGRAMME DISPOW.FOR

The computer programme DISPOW.FOR is written in FORTRAN IV language and run on VAX 11/780 digital computer system. The program is meant for estimation of missing rainfall data using the distance power method. The programme uses information on the latitude and longitude as provided by the user and computes the distance of each estimator station from the station whose data is estimated. The station whose data is to be estimated is to be treated as station 1 and its details provided first.

The programme makes use of the 'station characteristics' as provided by the user to adjust the data. The programme can also be used to test the consistency of the data at a particular station. Some of the important variables used in the programme are described.

VARIABLE	DESCRIPTION
NST	Number of stations including the station whose data is estimated. Normally four stations from around the estimated station are used.
NVAL	Number of values to be estimated. Programme provides for upto 20 values.
NPOW	Number of powers to be tried. Upto lo can be used.
POW	Value of power to be used with the distance

ST1,ST2,ST3,ST4	Name of station (upto 16 letters)
LAT,LONG	Latitude and longitude of the raingauge station
STNCH(I,J)	Two dimensional array containing the station characteristics for adjusting different values and for the different stations.
RF(I,J)	Two dimensional array containing the rainfall data (hourly, daily, monthly or seasonal) of different stations for the different periods.
WT(I)	Weight of each estimator station obtained by the distance power weighting.
ERF	Estimated rainfall
DRF	Difference between observed and estimated rainfall squared.

C. INPUT SPECIFICATIONS

The input data is given through an input data file DIS.DAT and consists of two control cards followed by information on the station name, its latitude and longitude, station characteristics and rainfall data for the period for which the data need to be estimated. A copy of the sample input data file is provided.

D. OUTPUT SPECIFICATIONS

Tne output file DIS.OUT consists of the distance of each of the estimator stations from the estimated station, the power(s) used for weighting the distance, weights obtained, observed rainfall, estimated rainfall and the difference between the observed and estimated rainfall squared. The specifications are indicated below.

REC.NO.	OUTPUT LIST	FORMAT	REMARKS
1.	...	Interpolated rainfall of ... from...	Names of stations
2.	ST1,ST,ST3 ST4...DIST(I)	Distance of 4A4 From 4A4,F10.1 in Kms.	Names of stations and their distances
3.	POW	2x,2oF6.3	
4.	WT(I),I=1,NS	2x,20F6.3	
5.	RF(1,K),K=1,NVAL	2x,20F6.1	All the data refers to the station 1 i.e. the station whose data is estimated.
6.	ERF(I),I=1,NVAL	2x,20F6.1	
7.	DRF(I),I=1,NVAL	2x,20F6.1	

A sample output is provided for reference.

Example:

In the example whose sample input is provided, nine values of ten daily rainfall have been considered. Data at Baudhgarh is estimated using the data for the corresponding periods at Phulbani, Krishnanagar, Atmalik and Khejuripara. The station characteristics of the stations used for estimation and of the station whose data are estimated are given below. Phulbani observatory has been considered as the base station and that is why its station characteristics are 1.00 in all the months.

Station	Station characteristics		
Baudhgarh	1.01	1.06	1.05
Phulbani	1.00	1.00	1.00
Krishnanagar	0.92	1.23	1.14
Athmalik	1.17	1.10	1.01
Khejuripara	0.95	0.88	0.99

The observed data at Baudhgarh are compared with the estimated rainfall values and the square of the difference computed.

INPUT DATA FILE

```
05,09,01
2,0
  BAUDHGARH      20838432
1.01,1.01,1.01,1.06,1.06,1.06,1.05,1.05,1.05
33.2,125.2,199.0,307.0,28.0,86.6,62.6,7.8,89.0
  PHULBANI       20498423
1.00,1.00,1.00,1.00,1.00,1.00,1.00,1.00,1.00
23.8,105.6,115.0,330.2,13.9,106.8,46.0,36.6,134.4
  KRISHNANAGAR   20978447
0.92,0.92,0.92,1.23,1.23,1.23,1.14,1.14,1.14
42.8,84.1,266.6,187.0,7.0,195.4,66.6,40.8,97.4
  ATHMALIK       20728453
1.17,1.17,1.17,1.10,1.10,1.10,1.01,1.01,1.01
127.5,48.1,229.1,271.1,17.5,101.6,153.2,19.6,57.6
  KHE.BIRIPARA   20438442
0.95,0.95,0.95,0.88,0.88,0.88,0.99,0.99,0.99
110.0,40.0,28.4,278.4,22.1,125.1,59.9,233.3,76.9
```

OUTPUT FILE

```
INTERPOLATED RAINFALL FOR  BAUDHGARH    FROM  PHULBANI        KRISHNANAGAR    ATHMALIK        KHE.BIRIPARA
DISTANCE OF   PHULBANI       FROM  BAUDHGARH     IS      29.8KMS
DISTANCE OF   KRISHNANAGAR   FROM  BAUDHGARH     IS      22.6KMS
DISTANCE OF   ATHMALIK       FROM  BAUDHGARH     IS      26.1KMS
DISTANCE OF   KHE.BIRIPARA   FROM  BAUDHGARH     IS      45.4KMS
 2,000
 0.139 0.431 0.323 0.107
  33.2 125.2 199.0 307.0  28.0  86.6  62.6   7.8  89.0
  71.6  72.6 209.5 238.3  12.9 136.1  91.4  54.2  90.8
 1478, 2748,  109, 4715,  227, 2447,  929, 2154,   67,
```

APPENDIX - I V

A. COMPUTER PROGRAMME DOUBLE.FOR

```
C       THIS PROGRAMME CHECKS THE CONSISTENCY OF A PARTICULAR
C       RECORD USING DOUBLE MASS CURVE ANALYSIS HERE:
C       NS=NO. OF RAIGAUGE STATIONS
C       N=NO. OF OBSERVATIONS AT EACH STATIONS
C       NT=STATION NO. FOR WHICH ANALYSIS IS REQUIRED
C       R=MATRIX HAVING OBSERVATIONS AT DIFFERENT RAINGAUGE
C       STATIONS WHERE RAINFALL VALUES ARE SUPLIED COLUMN VISE
        DIMENSION R(20,100)
        OPEN(UNIT=1,FILE='DOUBLE.DAT',STATUS='OLD')
        OPEN(UNIT=2,FILE='DOUBLE.OUT',STATUS='NEW')
        READ(1,*) NS,N,NT
        READ(1,*) ((R(J,I),I=1,N),J=1,NS)
        WRITE(2,7)
7       FORMAT(20X,'DOUBLE MASS CURVE ANALYSIS')
        WRITE(2,8)
8       FORMAT(20X,27('_')///)
        WRITE(2,6)NT
6       FORMAT(5X,'STATION NO.',I3,28X,'SUM OF OTHER STATIONS')
        A=0.0
        B=0.0
        DO 1 I=1,N
        DO 2 J=1,NS
        IF(J.EQ.NT) GO TO 3
        A=A+R(J,I)
        X=A/(NS-1)
        GO TO 2
3       B=B+R(J,I)
2       CONTINUE
        WRITE(2,5) B,X
5       FORMAT(5X,F10.2,31X,F12.2)
1       CONTINUE
        CLOSE(UNIT=1)
        CLOSE(UNIT=2)
        STOP
        END
```

B. DESCRIPTION OF COMPUTER PROGRAMME DOUBLE.FOR

The computer programme DOUBLE.FOR checks the consistency of a particular record using double mass curve analysis. The programme is written in FORTRAN IV language and run on VAX-11/780 digital computer system. The important variables used in the main programme are described below:

VARIABLE	DESCRIPTION
NS	No. of raingauge stations
N	No. of observations at each stations
NT	Station no. at which consistency check of the record is required
R	Two dimensional array containing the observed rainfall values at different stations
B	Cumulative fall at the selected raingauge station for the consistency check
X	Average of cumulative falls at other raingauge stations excluding the one selected for consistency check.

C. INPUT SPECIFICATIONS:

The input data file DOUBLE.DAT consists the following input lists in the specified format.

REC No.	INPUT LISTS	FORMAT	REMARK
1.	NS, N, NT	FREE	
2.	((R(J,I),I=1,N), J=1, NS)	FREE	

D. OUTPUT SPECIFICATIONS:

The output file DOUBLE.OUT consists the following output lists in the specified format.

<table>
<tr><th>RECNo.</th><th>OUTPUT LISTS</th><th>FORMAT</th><th>REMARK</th></tr>
<tr><td>1.</td><td>Nil</td><td>20X, 'DOUBLE MASS CURVE ANALYSIS'</td><td></td></tr>
<tr><td>2.</td><td></td><td></td><td></td></tr>
<tr><td>2.</td><td>Nil</td><td>20X, 27('-')|||</td><td></td></tr>
<tr><td>3.</td><td>NT</td><td>5X, 'STATION NO.',I3,28X,
'SUM OF OTHER STATIONS'</td><td></td></tr>
<tr><td>4.</td><td>B, X</td><td>5X, F10.2, 31X, F12.2</td><td></td></tr>
</table>

E. EXAMPLE

The annual rainfall values for five stations all in the same catchment area are given below. Develop a programme to check the consistency of different stations using double mass technique.

Year	stn 1	stn 2	stn 3	stn 4	stn 5
1973	43.54	40.10	44.21	39.17	39.91
1974	48.80	47.54	48.41	43.34	45.15
1975	47.57	46.77	47.50	42.28	42.74
1976	43.15	43.26	43.86	35.02	33.12
1977	45.03	44.91	50.95	37.86	48.91
1978	45.99	47.06	43.10	37.36	37.15
1979	40.41	40.16	38.97	35.71	40.77
1980	63.77	61.75	60.57	52.23	54.07

(a) Input :

The input data to check the conistency of records at a station wing the double mass curve technique are supplied through the file DOUBLE.DAT. For the above example, the input file DOUBLE.DAT contains the following data to run the programme for checking the consistency of records at station no.1.

```
5 8 1
43.54  48.80  47.57  43.15  45.03  45.99  40.41  63.77
40.10  47.54  46.77  43.26  44.91  47.06  40.16  61.75
44.21  48.41  47.50  43.86  50.96  43.10  38.94  60.57
39.17  43.34  42.28  35.02  37.86  37.36  35.71  52.23
39.91  45.15  42.74  33.12  48.91  37.15  40.77  54.07
```

(b) Output :

DOUBLE MASS CURVE ANALYSIS

STATION NO.1	SUM OF OTHER STATIONS
43.54	40.85
92.34	86.96
139.91	131.78
183.06	170.60
228.09	216.25
274.08	257.42
314.49	296.32
378.26	353.47

APPENDIX V

A. COMPUTER PROGRAMME TENDAY.FOR

```
C       PROGRAMME TO READ DATA FROM IMD TAPES AND OTHER SOURCE
C       CONDITIONS! IT WILL NOT TAKE CARE OF CONTINUOUS YEAR DATA
C                 !THEREFOR,FOR WATERYEAR CALCULATIONS NOT APPLICABLE

        DIMENSION IR(12,31),NDAY(12),SUMMON(100,13),DAYS(50,12,3)
        1,K(50,12,3),SUMYR(50),NNDAY(50,12),AVER(50,12,3),AVMON(
        250,12),KK1(50,12),NYEAR(50),NNYEAR(50),AMON(50)
        CHARACTER*10 ANSTAT
        CHARACTER*16 ANDIST,ANSTN
        DATA NDAY/31,28,31,30,31,30,31,31,30,31,30,31/
        OPEN(UNIT=1, FILE= 'WORK9.DAT', STATUS ='OLD')
        OPEN(UNIT=2, FILE= 'WORK.OUT', STATUS ='NEW')
        GO TO 777
 888    BACKSPACE(UNIT=1)
 777    READ(1,109)NOSTAT,NODIST,ANSTAT,ANDIST,ANSTN
 109    FORMAT(2I2,A,2A/)
        WRITE(2,104)
        WRITE(2,5000)ANSTAT,ANDIST,ANSTN
 5000   FORMAT(2X,'STATE-',A10,15X,'DIST-',A16,15X,'STATION-',A16)
        NYR=1000
        DO 40 II=1,NYR
        DO 10 I=1,12
        READ(1,101,ERR=111,END=999)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,
        2(IR(I,J),J=1,15)
C       WRITE(2,101)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,
C       2(IR(I,J),J=1,15)
        IYEAR=IYEAR+1900
        IF(LAT.EQ.'  ')GO TO 111
        IF(I.EQ.2) CALL LEAPYR(IYEAR,NDAY)
        READ(1,101,END=999)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,(IR(I,J),
        1 J=16,NDAY(I))
C       WRITE(2,101)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,(IR(I,J),
C       1 J=16,NDAY(I))
 10     CONTINUE
        GO TO 222
 111    BACKSPACE (UNIT=1)
        DO 50 K9=1,31
        READ(1,105,ERR=888,END=999)ICATNO,STR,LAT,LONG,ISTANO,IYEAR,IDATE,
        1(IR(J,K9),J=1,12)
 50     CONTINUE
 222    CALL TENDAY(II,IR,NDAY,IYEAR,DAYS,K,NNDAY,AVER)
        CALL SUM(II,DAYS,SUMMON,SUMYR,AVMON,K,NDAY,KK1,AMON)
        NYEAR(II)=IYEAR
        CALL OUT(II,NYEAR,NNYEAR,DAYS,K,NDAY,KK1,SUMMON,SUMYR,AVMON
        1,AVER,AMON)
 40     CONTINUE
 104    FORMAT(4X,128('*'))
 101    FORMAT(1X,I3,A2,2I2,2X,2I2,I1,16I4)
 105    FORMAT(1X,I3,A2,2I4,I2,4X,I4,I2,12I4)
 999    STOP
        END
C
```

```
      SUBROUTINE LEAPYR (IYEAR,NDAY)
C     YEAR SHOULD BE DEFINED IN FULL DIGITS IN MAIN PROGRAMME
      DIMENSION NDAY(2)
      LPYR=MOD(IYEAR,4)
      IF(LPYR.EQ.0) NDAY(2)=29
      RETURN
      END
C     ***********************************************************
      SUBROUTINE TENDAY(II,IR,NDAY,IYEAR,DAYS,K,NNDAY,AVER)
      DIMENSION DAYS10(12),DAYS20(12),DAYRES(12),R(12,31),IR(12,31)
     1,NDAY(12),K1(12),K2(12),K3(12),DAYS(50,12,3),K(50,12,3),
     2AVER(50,12,3),AV10(12),AV20(12),AVRES(12),NNDAY(50,12)
     3,AK1(12),AK2(12),AK3(12)
      IF(IYEAR.LT.1600)IYEAR=IYEAR+1900
      DO 1 I=1,12
      NDAY(2)=28
      IF(I.EQ.2) CALL LEAPYR(IYEAR,NDAY)
      NDAYS=NDAY(I)
      DO 2 J=1,NDAYS
      R(I,J)=IR(I,J)
      IF(R(I,J).EQ.-999)GO TO 9875
C     TYPE *,IYEAR
      IF(IYEAR.LE.1957) GO TO 9849
      R(I,J)=R(I,J)/10.0
      GO TO 2
 9849 R(I,J)=R(I,J)*0.254
      GO TO 2
 9875 R(I,J)=R(I,J)/10.0
    2 CONTINUE
      DAYS10(I)=0.0
      DAYS20(I)=0.0
      DAYRES(I)=0.0
      K1(I)=0
      K2(I)=0
      K3(I)=0
      DO 3 J=1,NDAYS
      IF(J.GT.10.AND.J.LE.20) GO TO 41
      IF(J.GT.20) GO TO 42
      IF(R(I,J).NE.-99.9) K1(I)=K1(I)+1
      IF(R(I,J).EQ.-99.9) GO TO 3
      DAYS10(I)=DAYS10(I)+R(I,J)
      GO TO 3
   41 IF(R(I,J).NE.-99.9) K2(I)=K2(I)+1
      IF(R(I,J).EQ.-99.9) GO TO 3
      DAYS20(I)=DAYS20(I)+R(I,J)
      GO TO 3
   42 IF(R(I,J).NE.-99.9) K3(I)=K3(I)+1
      IF(R(I,J).EQ.-99.9) GO TO 3
      DAYRES(I)=DAYRES(I)+R(I,J)
    3 CONTINUE
      IF(K1(I).EQ.0) GO TO 43
      AK1(I)=K1(I)
      AV10(I)=DAYS10(I)/AK1(I)
      GO TO 44
```

```
43      DAYS10(I)=-99
        AV10(I)=-99
44      IF(K2(I).EQ.0) GO TO 45
        AK2(I)=K2(I)
        AV20(I)=DAYS20(I)/AK2(I)
        GO TO 46
45      DAYS20(I)=-99
        AV20(I)=-99
46      IF(K3(I).EQ.0) GO TO 47
        AK3(I)=K3(I)
        AVRES(I)=DAYRES(I)/AK3(I)
        GO TO 48
47      DAYRES(I)=-99
        AVRES(I)=-99
48      DAYS(II,I,1)=DAYS10(I)
        DAYS(II,I,2)=DAYS20(I)
        DAYS(II,I,3)=DAYRES(I)
        K(II,I,1)=K1(I)
        K(II,I,2)=K2(I)
        K(II,I,3)=K3(I)
        AVER(II,I,1)=AV10(I)
        AVER(II,I,2)=AV20(I)
        AVER(II,I,3)=AVRES(I)
        NNDAY(II,I)=NDAY(I)
1       CONTINUE
        RETURN
        END
C       ***********************************************************
        SUBROUTINE SUM(II,DAYS,SUMMON,SUMYR,AVMON,K,NDAY,KK1,AMON)
        DIMENSION DAYS(50,12,3),SUMMON(50,12),SUMYR(50),AVMON(50,12)
        1,K(50,12,3),NDAY(12),KK1(50,12),AKK1(50,12),AMON(50)
        SUMYR(II)=0.0
        DO 20 I=1,12
        SUMMON(II,I)=0.0
        KK1(II,I)=0.0
        DO 30 J=1,3
        IF(DAYS(II,I,J).EQ.-99) GO TO 30
        SUMMON(II,I)=SUMMON(II,I)+DAYS(II,I,J)
        KK1(II,I)=KK1(II,I)+K(II,I,J)
30      CONTINUE
        SUMYR(II)=SUMYR(II)+SUMMON(II,I)
        IF(KK1(II,I).EQ.0) GO TO 32
        AKK1(II,I)=KK1(II,I)
        AVMON(II,I)=SUMMON(II,I)/AKK1(II,I)
        GO TO 20
32      AVMON(II,I)=-99
        SUMMON(II,I)=-99
20      CONTINUE
        AMON(II)=0.0
        DO 300 I=6,10
        IF(SUMMON(II,I).EQ.-99)GO TO 300
        AMON(II)=AMON(II)+SUMMON(II,I)
        IF(AMON(II).EQ.0.0) AMON(II)=-99
300     CONTINUE
        RETURN
        END
```

```
C     **************************************************************
      SUBROUTINE OUT(II,NYEAR,NNYEAR,DAYS,K,NDAY,KK1,SUMMON,SUMYR
     1,AVMON,AVER,AMON)
      DIMENSION NYEAR(50),NNYEAR(50),DAYS(50,12,3),K(50,12,3),NDAY(12)
     1,KK1(50,12),SUMMON(50,12),SUMYR(50),AVMON(50,12),AVER(50,12,3)
     2,AMON(50)
      WRITE(2,199)
  199 FORMAT(14X,'TEN DAILY RAINFALL (MM)')
      IF(NYEAR(II).LT.1900) NYEAR(II)=NYEAR(II)+1900
      WRITE(2,201) NYEAR(II)
  201 FORMAT(4X,'YEAR-',I4)
      WRITE(2,104)
  104 FORMAT(4X,129('*'))
      WRITE(2,202)
  202 FORMAT(4X,'NO',4X,'JAN',7X,'FEB',7X,'MAR',7X,'APR',7X,'MAY',
     17X,'JUN',7X,'JUL',7X,'AUG',7X,'SEP',7X,'OCT',7X,'NOV',7X,'DEC')
      WRITE(2,104)
      WRITE(2,203)
  203 FORMAT(8X,'TR1',2X,'NU1',2X,'TR2',2X,'NU2',2X,'TR3',2X,'NU3',2X,
     1'TR4',2X,'NU4',2X,'TR5',2X,'NU5',2X,'TR6',2X,'NU6',2X,'TR7',2X,
     2'NU7',2X,'TR8',2X,'NU8',2X,'TR9',2X,'NU9',1X,'TR10',1X,'NU10',
     31X,'TR11',1X,'NU11',1X,'TR12',1X,'NU12')
      WRITE(2,104)
      DO 204 J=1,3
      K9=J
      WRITE(2,205) K9,(DAYS(II,I,J),K(II,I,J),I=1,12)
  204 CONTINUE
  205 FORMAT(4X,I2,12(1X,F5.0,2X,I2))
      WRITE(2,104)
      WRITE(2,206) (SUMMON(II,I),KK1(II,I),I=1,12)
  206 FORMAT(1X,'SUM=',12(2X,F5.0,1X,I2))
      WRITE(2,104)
      WRITE(2,212) SUMYR(II)
  212 FORMAT(4X,'ANNUAL RAINFALL(MM)=',F10.2)
      WRITE(2,641) AMON(II)
  641 FORMAT(4X,'TOTAL RAINFALL IN MONSOON SEASON(MM)=',F10.2)
      WRITE(2,104)
      WRITE(2,341)
  341 FORMAT(2X,'WHERE:-'/4X,'TR..=TOTAL RAINFALL (MM)'/4X,'NU.,=
     1NO. OF VALUES AVAILABLE')
      WRITE(2,207)
  207 FORMAT(14X,'TEN DAILY AVERAGE RAINFALL(MM)')
      WRITE(2,201) NYEAR(II)
      WRITE(2,104)
      WRITE(2,202)
      WRITE(2,104)
      WRITE(2,303)
  303 FORMAT(8X,'AR1',2X,'NU1',2X,'AR2',2X,'NU2',2X,'AR3',2X,'NU3',2X,
     1'AR4',2X,'NU4',2X,'AR5',2X,'NU5',2X,'AR6',2X,'NU6',2X,'AR7',2X,
     2'NU7',2X,'AR8',2X,'NU8',2X,'AR9',2X,'NU9',1X,'AR10',1X,'NU10',
     31X,'AR11',1X,'NU11',1X,'AR12',1X,'NU12')
      WRITE(2,104)
      DO 209 J=1,3
      WRITE(2,205)J,(AVER(II,I,J),K(II,I,J),I=1,12)
  209 CONTINUE
```

```
      WRITE(2,104)
      WRITE(2,210) (AVMON(II,I),I=1,12)
210   FORMAT(1X,'MON AV=',F4.0,4X,F6.2,4X,F6.2,4X,F6.2,4X,F6.2,4X,F6.2
     1,4X,F6.2,4X,F6.2,4X,F6.2,4X,F6.2,4X,F6.2,4X,F6.2)
      WRITE(2,104)
      WRITE(2,530)
530   FORMAT(2X,'WHERE:-'/4X,'AR. =AVERAGE RAINFALL (MM)'/4X,'NO.,=
     1NO. OF VALUES')
      WRITE(2,531)
531   FORMAT('1')
      RETURN
      END
```

B. DESCRIPTION OF COMPUTER PROGRAMME TENDAY.FOR

The computer programme TENDAY.FOR is written in FORTRAN IV language and run on VAX-11/780 digital computer system. The programme uses the output file from the TAPE.FOR to compute the ten daily rainfall totals and the average rainfall during the ten day period. If the data for any day or days is missing during the ten day period, the total is computed for the available number of days and the average computed on the basis of the number of days for which data are available. Besides, the monthly, monsoon season and annual total rainfall are also computed. Some of the important variables used in the program are described below.

VARIABLE	DESCRIPTION
NDAY	Number of days in different calendar months
NOSTAT	Code Number of state
NODIST	Code number of district
AMSTAT	Name of the state in the country
AMDIST	Name of the district in the state
AMSTN	Name of the station in the district
IYEAR	Calendar year for which data is provided
IR(I,J) and R(I,J)	Two dimensional array containing daily rainfall data (together with -999 for the missing period) of raingauge stations.
DAYS 10 DAYS 20 DAYSRES	Ten daily rainfall totals of first ten days, second ten days, and the remaining days respectively.

K1, K2, K3	Actual number of days for which data are available in each of the periods above.
AV10, AV20, AVRES	Average daily rainfall during the first ten days, second ten days, and the remaining days.
SUMMON	Monthly rainfall totals
AMON	Monsoon season total rainfall
SUMYR	Annual rainfall total

C. INPUT SPECIFICATIONS

As mentioned above, the input file for the programme TENDAY.FOR is the output file from the programme TAPE. FOR namely WORK9.DAT obtained by processing the data received on tapes from the India Meteorological Department. As mentioned earlier the file WORK9.DAT would contain -999 in place of the missing data. The input specifications are the same as those specified in the output specifications of WORK9.DAT for the programme TAPE.FOR. A sample input file of WORK9.DAT is provided.

D. OUTPUT SPECIFICATIONS

The output from the programme includes besides the header (state name, district name, station name), ten daily and monthly totals, monsoon season and annual total rainfall, average ten daily rainfall during the ten days period for each ten day duration and the average daily rainfall during the month. The output specifications are described below.

INPUT DATA FILE

```
1129M P      RAIPUR        MAINPUR

320  2017821414   1960 1000000000000000000000004300000312000000000000000
320  2017821414   1960 2000000100000000000000003705620191000000000000000
320  2017821414   1960 3000000280000000000000003502190140007700000000000
320  2017821414   1960 4000000000000000000000000000620030010600000000000
320  2017821414   1960 5000000000000000000000000000930010007000000000000
320  2017821414   1960 6000000000000000000000000011004000720020000000000
320  2017821414   1960 7000000000000000000000000063002000000000000000000
320  2017821414   1960 8000000000000000000000008500890035010200000000000
320  2017821414   1960 9000000000000000000000008200010003000100000000000
320  2017821414   19601000000000000000000000000000610000000600580000000
320  2017821414   19601100000000000000000000000900570000000000000000000
320  2017821414   19601200000000000000000047000000290021000000000000000
320  2017821414   19601300000000000000000020009000201150000003000000000
320  2017821414   19601400000000000000000000000000001900000002300000000
320  2017821414   1960150000-999000000000000000003701200000000000000000
320  2017821414   19601600000000000000000000830079001500000000000000000
320  2017821414   19601700000000000000000000960039009600000000000000000
320  2017821414   19601800000000000000000000010000000000000000000000000
320  2017821414   19601900000000000000-99900000004500000044016100000000000
320  2017821414   19602000000000000000000000000000100013000000000000000
320  2017821414   19602100000000000000000040030001180073009000000000000
320  2017821414   19602200000000000000000043000500370010015000000000000
320  2017821414   19602300000000000000000030004700610003014000000000000
320  2017821414   19602400000000000000000000000000590000008500000000000
320  2017821414   19602500000000000000000000011000000000191000000000000
320  2017821414   19602600000000000000000000021009700000220067000000000
320  2017821414   19602700000000000000000035001870058000000000000000000
320  2017821414   19602800000000000000000015300020009000000000000000000
320  2017821414   19602900000000000000000095002000900000005000000000000
320  2017821414   1960300000    00000000000010000000100086000000000000000
320  2017821414   1960310055    0000    0000    01100000    0000    0000

17 4ORISSA    CUTTACK        JAGATSINGPUR

320201686  60 11000000000000000000000000000000000000000000000000000000000
320201686  60 1200000000000000000000000000000000000000000000000000000005400700055
320201686  60 21000000000000000000000000000000000000000000000000000000000
320201686  60 220000000000000000000000000000000000070000000000000-999
320201686  60 31000000000000000000000000000000000000000000000000000000000
320201686  60 32000000000000000000000000000000000000000000000000000000000000000000
320201686  60 41000000000000000000000000000000000000000000000000000000000
320201686  60 42000000000000000000000000000000000000000000000000000000032
320201686  60 51000000950000000000000000000000000000650000000000000000000
320201686  60 52000000000000000000003000000000007400000000002400000000000000000000
320201686  60 61008300000043001300000015000000000000003502430000000000500011
320201686  60 62-999-999-999-999-999-999-999-999-999-999-999-999-999-999-999
320201686  60 71000200000000000000780077014700220734906750192000100000000002
320201686  60 7200000135000000600060011000900000000000060000005701000070000020063
320201686  60 81001400060008000000120000000000510121003900250000000000620129
320201686  60 820000005400150000000000000000090000004400020000000000000000000000
320201686  60 91000000000730002000000530146009800190006000000000000900000000
320201686  60 92000000000000000000230000002300450000000000000000000005200720009
320201686  60101003001340000000000180000018402750465000500640000000000000000
320201686  6010200140000022100000000000000000000000000000000000000000000000000
320201686  601110000000000000000000000000000000000000000000000000000000000
320201686  601120000001002170251001000000000000000000000000000000000000000
320201686  601210000000000000000000000000000000000000000000000000000000000
320201686  6012200000000000000000000000000000000000000000000000000000000000000
```

REC No.	OUTPUT LIST	FORMAT	REMARKS
1.	AMSTAT	'STATE-'A10,15x	Title
2.	AMDIST	'DIST-'A16,15x	"
3.	AMSTN	'STATION-',A16	"
4.	-	14x,'TENDAILY RAINFALL(MM)'"	
5.	NYEAR	4x,'YEAR-',I4	Calendar year
6.	-	4x'JAN'7x'FEB'7x, ...7x,'DEC'	Heading
7.	-	8x'TR1'2x'NV1'2X 'TR2'2x'NV2'2x.. ...'TR12'1x'NV12	Heading
8.	(DAYS(II,I,J), K(II,I,J),I=1,12)	12(1x,F5.0,2x,I2)	Ten daily total rainfall and number of days of data.
10.	(SUMMONS(II,I), KK1(II,I)=1,12)	1x,'SUM=' 12(2x,F5.0,1x,I2	Monthly total rain fall and number of days of data
11.	SUMYR(II)	4x,'ANNUAL RAINFALL (MM)=',F10.2	
12.	AMON(II)	4x'TOTAL RAINFALL IN MONSOON SEASON(MM)=' F10.2	
13.	-	'TEN DAILY AVERAGE RAIN FALL(MM)'	Heading
12.	AMON(II)	4x'TOTAL RAINFALL IN MONSOON SEASON(MM)=' F10.2	
13.	-	'TEN DAILY AVERAGE RAIN FALL(MM)'	Heading
14.	NYEAR(II)	4x,'YEAR-',I4	Calendar year
15.	-	8x,'AR1,2x,'NV1'2x 'AR2'2x'NV2' ...'AR12' x'NV12'	Heading
16.	J,AVER(II,I,J), K(II,I),I=1,12	4x,I 2,12(1x,F5.0,4X,2X,I2	Average daily rainfall during ten days period
17.	AVMON(II)	('MONAV=F4.0,4x,F6.2 ....4x,f6.2)	Average daily rainfall during the month

The sample output is provided from which the above specifications could be understood better. The first example is that of Raipur in Madhya Pradesh whose input is in the 31 card format. The second example is that of Cuttak in Orrissa, whose input is in the 24 card format.

OUTPUT FILE

STATE-UM P   DIST- RAIPUR   STATION- MAINPUR

TEN DAILY RAINFALL (MM)

YEAR-1960

NO	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	TR1	NU1	TR2	NU2	TR3	NU3	TR4	NU4	TR5	NU5	TR6	NU6	TR7	NU7	TR8	NU8	TR9	NU9	TR10	NU10	TR11	NU11	TR12	NU12
1	0.	10	4.	10	0.	10	0.	10	0.	10	28.	10	116.	10	80.	10	43.	10	8.	10	0.	10	0.	10
2	0.	10	0.	9	0.	10	0.	9	5.	10	24.	10	25.	10	59.	10	16.	10	5.	10	0.	10	0.	10
3	6.	11	0.	9	0.	11	0.	10	70.	11	59.	10	64.	11	17.	11	72.	10	7.	11	0.	10	0.	11
SUM=	6.	31	4.	29	0.	31	0.	29	75.	31	112.	30	205.	31	157.	31	131.	30	20.	31	0.	30	0.	31

ANNUAL RAINFALL(MM)= 709.00

TOTAL RAINFALL IN MONSOON SEASON(MM)= 624.60

WHERE!-

TR...=TOTAL RAINFALL (MM)

NU..=NO. OF VALUES AVAILABLE

TEN DAILY AVERAGE RAINFALL(MM)

YEAR-1960

NO	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	AR1	NU1	AR2	NU2	AR3	NU3	AR4	NU4	AR5	NU5	AR6	NU6	AR7	NU7	AR8	NU8	AR9	NU9	AR10	NU10	AR11	NU11	AR12	NU12
1	0.	10	0.	10	0.	10	0.	10	0.	10	3.	10	12.	10	8.	10	4.	10	1.	10	0.	10	0.	10
2	0.	10	0.	9	0.	10	0.	9	0.	10	2.	10	3.	10	6.	10	2.	10	1.	10	0.	10	0.	10
3	1.	11	0.	9	0.	11	0.	10	6.	11	6.	10	6.	11	2.	11	7.	10	1.	11	0.	10	0.	11
MON AV=	0.		0.14		0.00		0.00		2.42		3.73		6.61		5.05		4.38		0.64		0.00		0.00	

WHERE!-

AR..=AVERAGE RAINFALL (MM)

NU..=NO. OF VALUES

STATE-ORISSA DIST- CUTTACK STATION- JAGATSINGPUR

TEN DAILY RAINFALL (MM)

YEAR-1960

NO	JAN TR1	NU1	FEB TR2	NU2	MAR TR3	NU3	APR TR4	NU4	MAY TR5	NU5	JUN TR6	NU6	JUL TR7	NU7	AUG TR8	NU8	SEP TR9	NU9	OCT TR10	NU10	NOV TR11	NU11	DEC TR12	NU12
1	0.	10	0.	10	0.	10	0.	10	16.	10	19.	10	135.	10	25.	10	39.	10	107.	10	0.	10	0.	10
2	0.	10	0.	10	0.	10	0.	10	0.	10	32.	5	34.	10	28.	10	3.	10	30.	10	49.	10	0.	10
3	18.	11	1.	9	0.	11	3.	10	8.	11	-99.	0	31.	11	6.	11	20.	10	0.	11	0.	10	0.	11
SUM=	18.	31	1.	29	0.	31	3.	30	24.	31	51.	15	201.	31	59.	31	63.	30	137.	31	49.	30	0.	31

ANNUAL RAINFALL(MM)= 605.30

TOTAL RAINFALL IN MONSOON SEASON(MM)= 510.60

WHERE!-

TR...=TOTAL RAINFALL (MM)

NU..=NO. OF VALUES AVAILABLE

TEN DAILY AVERAGE RAINFALL(MM)

YEAR-1960

NO	JAN AR1	NU1	FEB AR2	NU2	MAR AR3	NU3	APR AR4	NU4	MAY AR5	NU5	JUN AR6	NU6	JUL AR7	NU7	AUG AR8	NU8	SEP AR9	NU9	OCT AR10	NU10	NOV AR11	NU11	DEC AR12	NU12
1	0.	10	0.	10	0.	10	0.	10	2.	10	2.	10	14.	10	3.	10	4.	10	11.	10	0.	10	0.	10
2	0.	10	0.	10	0.	10	0.	10	0.	10	6.	5	3.	10	3.	10	0.	10	3.	10	5.	10	0.	10
3	2.	11	0.	9	0.	11	0.	10	1.	11	-99.	0	3.	11	1.	11	2.	10	0.	11	0.	10	0.	11
MON AV=	1.		0.03		0.00		0.11		0.78		3.42		6.47		1.90		2.09		4.42		1.63		0.00	

WHERE!-

AR..=AVERAGE RAINFALL (MM)

NU..=NO. OF VALUES

APPENDIX VI

A. COMPUTER PROGRAMME MAX.FOR

```
C       THIS PROGRAMME COMPUTES THE ONE TWO THREE FOUR AND FIVE DAY
C       RAINFALL TOTALS
C       THIS PROGRAMME USES THE OUTPUT FROM THE PROGRAMME TAPE.FOR

        DIMENSION IR(12,31),R2(12,31),R3(12,31),R4(12,31),R5(12,31),
        1R(12,31),NDAY(12),AMAX(12),IT(12)
        CHARACTER*10 AMSTAT
        CHARACTER*16 AMDIST,AMSTN
        DATA NDAY/31,28,31,30,31,30,31,31,30,31,30,31/
        OPEN(UNIT=1, FILE= 'MAX.DAT', STATUS ='OLD')
        OPEN(UNIT=2, FILE= 'MAX.OUT', STATUS ='NEW')
        GO TO 777
888     BACKSPACE(UNIT=1)
777     READ(1,109)NOSTAT,NODIST,AMSTAT,AMDIST,AMSTN
109     FORMAT(1X,2I2,A,2A/)
        WRITE(2,600)
        WRITE(2,500)AMSTAT,AMDIST,AMSTN
500     FORMAT(/2X,'STATE-  ',A10,15X,'DIST-',A16,15X,'STATION-',A16)
600     FORMAT(32X,'MAXIMUM 1 DAY,2 DAY,3 DAY,4 DAY AND 5 DAY RAINFALL')
        WRITE(2,700)
700     FORMAT(2X,40('-+-'))
        DO 10 I=1,12
        READ(1,101,ERR=111,END=999)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,ICRDNO,
        2(IR(I,J),J=1,15)
        IYEAR=IYEAR+1900
        IF(LAT.EQ.'  ')GO TO 111
        IF(I.EQ.2) CALL LEAPYR(IYEAR,NDAY)
        READ(1,101,END=999)ICATNO,LAT,LONG,ISTANO,IYEAR,IMONTH,
        1ICRDNO,(IR(I,J),J = 16,NDAY(I))
10      CONTINUE
        GO TO 222
111     BACKSPACE (UNIT=1)
        DO 50 K=1,31
        READ(1,105,ERR=888,END=999)ICATNO,STR,LAT,LONG,ISTANO,IYEAR,
        1IDATE,(IR(J,K),J=1,12)
50      CONTINUE
222     CALL SUM(IYEAR,NDAY,IR,R,R2,R3,R4,R5)
        CALL MAXIM(IYEAR,NDAY,R,YMAX1,IT1B,IT1E,IMB1,IME1,1)
        CALL MAXIM(IYEAR,NDAY,R2,YMAX2,IT2B,IT2E,IMB2,IME2,2)
        CALL MAXIM(IYEAR,NDAY,R3,YMAX3,IT3B,IT3E,IMB3,IME3,3)
        CALL MAXIM(IYEAR,NDAY,R4,YMAX4,IT4B,IT4E,IMB4,IME4,4)
        CALL MAXIM(IYEAR,NDAY,R5,YMAX5,IT5B,IT5E,IMB5,IME5,5)
        WRITE(2,800)
        WRITE(2,900) IYEAR,YMAX1,YMAX2,YMAX3,YMAX4,YMAX5
        WRITE(2,1000) IT1B,IMB1,IT1E,IME1,IT2B,IMB2,IT2E,IME2,IT3B,IMB3
        1,IT3E,IME3,IT4B,IMB4,IT4E,IME4,IT5B,IMB5,IT5E,IME5
        WRITE(2,700)
800     FORMAT(2X,'  YEAR  ' 8X' MAX  1  DAY' 9X' MAX  2  DAYS' 9X' MAX
        1  3  DAYS' 9X,' MAX  4  DAYS' 9X,' MAX  5  DAYS'/)
900     FORMAT(2X,I6,5(15X,F6.1)/)
1000    FORMAT(8X,5( 8X,I2'/'I2' I[illegible]2'/'I2))
101     FORMAT(1X,I3,A2,2I2,2X,2I2,I1,16I4)
105     FORMAT(1X,I3,A2,2I4,I2,4X,I4,I2,12I4)
999     STOP
        END
```

```
      SUBROUTINE SUM(IYEAR,NDAY,IR,R,R2,R3,R4,R5)
C     SUBROUTINE FOR SUMMING ONE DAY,TWO DAY,THREE DAY,FOUR DAY AND
C     FIVE DAY TOTALS OF RAINFALL
      DIMENSION IR(12,31),R2(12,31),R3(12,31),R4(12,31),R5(12,31),
     1R(12,31),NDAY(12)
      IF (IYEAR.LT.1600) IYEAR = IYEAR +1900
      DO 10 I = 1,12
      IF (I.EQ.2) CALL LEAPYR (IYEAR,NDAY)
      ND = NDAY (I)
      DO 15 J = 1,ND
      R(I,J) = IR(I,J)
      IF (R(I,J).EQ.-999) GO TO 999
      IF (IYEAR.LE.1957) GO TO 888
      R(I,J) = R(I,J) / 10.0
      GO TO 15
  888 R(I,J) = R(I,J) * 0.254
      GO TO 15
  999 R(I,J) = R(I,J) / 10.0
   15 CONTINUE
      DO 20 J = 1,ND
      IF (R(I,J).EQ.-99.9) GO TO 20
      IF (J.EQ.ND) GO TO 11
      IF (R(I,J+1).EQ.-99.9) GO TO 20
      R2 (I,J) =  R(I,J) +  R(I,J+1)
      GO TO 12
   11 IF (R(I+1,1).EQ.-99.9) GO TO 20
      R2 (I,J) = R(I,J) + R(I+1,1)
      IF (R(I+1,2).EQ.-99.9) GO TO 20
      R3 (I,J) =R2(I,J) + R(I+1,2)
      IF (R(I+1,3).EQ.-99.9) GO TO 20
      R4 (I,J) = R3(I,J) + R(I+1,3)
      IF (R(I+1,4).EQ.-99.9) GO TO 20
      R5 (I,J) = R4(I,J) + R(I+1,4)
      GO TO 20
   12 IF (J.EQ.ND-1) GO TO 13
      IF (R(I,J+2).EQ.-99.9) GO TO 20
      R3 (I,J) = R2(I,J) + R(I,J+2)
      GO TO 14
   13 IF (R(I+1,1).EQ.-99.9) GO TO 20
      R3 (I,J) = R2(I,J) + R(I+1,1)
      IF (R(I+1,2).EQ.-99.9) GO TO 20
      R4 (I,J) = R3(I,J) + R(I+1,2)
      IF (R(I+1,3).EQ.-99.9) GO TO 20
      R5 (I,J) = R4(I,J) + R(I+1,3)
      GO TO 20
   14 IF (J.EQ.ND-2) GO TO 16
      IF (R(I,J+3).EQ.-99.9) GO TO 20
      R4 (I,J) = R3(I,J) + R(I,J+3)
      GO TO 17
   16 IF (R(I+1,1).EQ.-99.9) GO TO 20
      R4 (I,J) = R3(I,J) + R(I+1,1)
      IF (R(I+1,2).EQ.-99.9) GO TO 20
      R5 (I,J) = R4(I,J) + R(I+1,2)
      GO TO 20
   17 IF (J.EQ.ND-3) GO TO 18
      IF (R(I,J+4).EQ.-99.9) GO TO 20
      R5 (I,J) = R4(I,J) + R(I,J+4)
      GO TO 20
   18 IF (R(I+1,1).EQ.-99.9) GO TO 20
      R5 (I,J) = R4(I,J) + R(I+1,1)
   20 CONTINUE
   10 CONTINUE
      RETURN
      END
```

```
C       ***********************************************

        SUBROUTINE MAXIM(IYEAR,NDAY,R,AMMAX,ITTB,ITTE,IMNB,IMNE,N)
C       SUBROUTINE FOR COMPUTING MAXIMUM RAINFALL TOTALS
        DIMENSION R(12,31),NDAY(12),AMAX(12),IT(12)
        DO 10 I= 1,12
        IF(I.EQ.2)CALL LEAPYR(IYEAR,NDAY)
        ND=NDAY(I)
        AMAXM= R(I,1)
        IPT = 1
        DO 20 J=2,ND
        IF(AMAXM.GE. R(I,J)) GO TO 20
        AMAXM= R(I,J)
        IPT=J
20      CONTINUE
        AMAX(I)=AMAXM
        IT(I)=IPT
10      CONTINUE
        AMMAX=AMAX (1)
        IPB=IT(1)
        IMK = 1
        DO 15 I= 2,12
        IF(AMMAX.GE.AMAX(I))GO TO 15
        AMMAX=AMAX(I)
        IPB = IT(I)
        IMK=I
15      CONTINUE
        ITTB = IPB
        IMNB = IMK
        IPE = IPB + (N-1)
        IF (NDAY(IMK).GE.IPE) GO TO 25
        ITTE = IPE - NDAY(IMK)
        IMNE = IMK + 1
        GO TO 30
 25     ITTE = IPE
        IMNE = IMK
 30     RETURN
        END

C       ****************************************************

        SUBROUTINE LEAPYR (IYEAR,NDAY)
        DIMENSION NDAY(2)
        LPYR = MOD(IYEAR,4)
        IF (LPYR.EQ.0) NDAY(2)=29
        RETURN
        END
```

B. DESCRIPTION OF COMPUTER PROGRAMME

The computer programme MAX.FOR is meant for the computation of the maximum 1 day, 2 days, 3 days, 4 days and 5 days rainfall from the daily rainfall data processed for missing rainfall amounts. The programme is written in the FORTRAN-IV language and has been run on the VAX-11/780 computer system. The programme comprises of a Main programme and three subroutines, SUM, MAXIM and LEAPYR. The variables used in the programme are described below.

VARIABLE	DESCRIPTION
AMSTAT,AMDIST,AMSTN	Name of state, district and station respectively
NDAY	Number of days in different months in a year.
IR	Daily rainfall data in the integer mode i.e. rainfall data written together with tenths of mm or cents of inches in four digits.
R,R2,R3,R4,R5	Rainfall totals corresponding to 1 day, 2 days, 3 days, 4 days and 5 days written as floating point variable with units in mm (inches are converted to mm)
AMAX(Subroutine MAXIM)	Maximum value of rainfall for the corresponding duration in each calendar month.

AMMAX(Subroutine MAXIM)	Annual maximum value of rainfall for the corresponding duration for each year
IPT(Subroutine MAXIM)	Day or dates of maximum rainfall in the month for the corresponding duration
IPB AND IPE (Subroutine MAXIM)	Day or dates of maximum rainfall in the year for the corresponding duration.
ITTB,ITTE IT1B,IT1E IT2B,IT2E IT3B,IT3E IT4B,IT4E IT5B,IT5E	Beginning and ending dates of the period corresponding to the maximum rainfall for the respective durations.
IMNB,IMNE IMB1,IME1 IMB2,IME2 IMB3,IME3 IMB4,IME4 IMB5,IME5	Beginning and ending months for periods starting in one months and ending in another month.
YMAX1,YMAX2,YMAX3, YMAX4,and YMAX5	Maximum rainfall corresponding to 1day,2day,3day,4day and 5 days.

C. INPUT SPECIFICATIONS

The programme uses the output file from the programme TAPE.FOR as input to this programme. The input specifications are the same as those given in the input specifications for the programme TENDAY.FOR. A sample of the input file MAX.DAT is given in this appendix.

INPUT DATA FILE

```
1129MP          RAIPUR                MAINPUR

320   2017821414     1960 1000000000000000000000000430000031200000000000000000
320   2017821414     1960 2000000000000000000000000370562019100000000000000000
320   2017821414     1960 3000000280000000000000000350219016000770000000000000
320   2017821414     1960 4000000000000000000000000000062003001060000000000000
320   2017821414     1960 5000000000000000000000000000009300100070000000000000
320   2017821414     1960 6000000000000000000000000000011004000720020000000000
320   2017821414     1960 7000000000000000000000000000063002000000000000000000
320   2017821414     1960 8000000000000000000000000850089003501020000000000000
320   2017821414     1960 9000000000000000000000000820001000300010000000000000
320   2017821414     19601000000000000000000000000000610000000600580000000000
320   2017821414     19601100000000000000000000000000570000000000000000000000
320   2017821414     19601200000000000000000000470000002800210000000000000000
320   2017821414     19601300000000000000000000200000002011500000003000000000
320   2017821414     19601400000000000000000000000000001800000002300000000000
320   2017821414     1960150000-999000000000000000000003701200000000000000000000
320   2017821414     19601600000000000000000000008300780015000000000000000000
320   2017821414     19601700000000000000000000009600390086000000000000000000
320   2017821414     19601800000000000000000000000001000000000000000000000000
320   2017821414     19601900000000000000-9990000004500000044016100000000000000
320   2017821414     19602000000000000000000000000000100013000000000000000000
320   2017821414     19602100000000000000000000400300011800730080000000000000
320   2017821414     19602200000000000000000000430005003700100150000000000000
320   2017821414     19602300000000000000000000300047006100030140000000000000
320   2017821414     19602400000000000000000000000000059000000850000000000000
320   2017821414     19602500000000000000000000000011000000000191000000000000
320   2017821414     19602600000000000000000000000021009700000022006700000000
320   2017821414     19602700000000000000000000350018700580000000000000000000
320   2017821414     19602800000000000000000000153000200080000000000000000000
320   2017821414     19602900000000000000000000085002000800000005000000000000
320   2017821414     1960300000      00000000000100000001000860000000000000000000
320   2017821414     1960310035      0000      0000      01100000      0000      0000
```

D. OUTPUT SPECIFICATIONS

The output file MAX.OUT consists of the name of the state , district and station followed by information regarding the maximum rainfall for different durations namely 1 day, 2 days, 3 days, 4 days and 5 days. The periods corresponding to these maximum amounts are also printed. The details of the output list are given below.

REC.No.	OUTPUT LIST	FORMAT	REMARKS
1.	Nil	32x,'MAXIMUM, 1 DAY,2DAY, 3 DAY,4 DAY AND 5DAY RAINFALL'	Title
2.	AMSTAT,AMDIST and AMSTN	2x,'STATE-'A10,15x 'DIST-'A16,15x, 'STATION-',A16)	Names of state, district and station printed
3.	Nil	2x,'YEAR,'8X'MAX 1DAY'...9X, MAX 5 DAYS'	Title
4.	IYEAR, YMAX1 ...YMAX5	2x, I6,5(15x,F6.1)	Calendar year and Maximum rainfall values printed
5.	IT1B,IMB1,IT1E, IME1....... IT5B,ITB5,IT5E, IME5.	8X,5(8X,I2'/I2'TO'I2/ 'I2)	Periods corresponding to maximum rainfall printed

A sample output of the programme is provided in this appendix.

E. MODIFICATIONS NECESSARY

The programme in its present form performs the computations for one station and one year at a time. The user may modify the programme by introducing appropriate statements before the STOP statement in the main programme to carry out the computations for more number of years or stations as desired.

OUTPUT FILE

MAXIMUM 1 DAY,2 DAY,3 DAY,4 DAY AND 5 DAY RAINFALL

STATE- MP DIST- RAIPUR STATION- MAINPUR

YEAR	MAX 1 DAY	MAX 2 DAYS	MAX 3 DAYS	MAX 4 DAYS	MAX 5 DAYS
1960	56.2	78.1	84.3	93.6	94.7
	2/ 7 TO 2/ 7	2/ 7 TO 3/ 7	2/ 7 TO 4/ 7	2/ 7 TO 5/ 7	2/ 7 TO 6/ 7

APPENDIX VII

A.COMPUTER PROGRAMME CATCH.FOR

```
C       PROGRAMME FOR COMPUTING CATCHMENT RAINFALL
        DIMENSION RAIN(20,100,40), AVRF(100,40), WT(20), NYR(100)
        OPEN (UNIT = 1, STATUS = 'OLD', FILE = 'CAT.DAT')
        OPEN (UNIT = 2, STATUS = 'NEW', FILE = 'CAT.OUT')
C       NSTN = NO. OF STATIONS, IYR = NO. OF YEARS
C       NVAL = NO. OF VALUES IN A YEAR
        READ (1,5) NSTN,IYR,NVAL
    5   FORMAT (3I2)
C       READ THIESSEN WEIGHTS OF STATIONS
        READ (1,10) (WT(I), I = 1,NSTN)
   10   FORMAT (20F8.2)
C       READ RAINFALL DATA FOR ALL YEARS STATION WISE
        DO 100 I = 1,NSTN
        DO 100 J = 1,IYR
        READ (1,*), NYR(J), (RAIN(I,J,K), K  = 1, NVAL)
  100   CONTINUE
C       COMPUTE CATCHMENT AVERAGE RAINFALL
        DO 300 J = 1,IYR
        DO 300 K = 1,NVAL
        AVRF (J,K) = 0.0
        DO 200 I = 1,NSTN
  200   AVRF (J,K) = AVRF(J,K) + RAIN (I,J,K) * WT(I)
  300   CONTINUE
        WRITE (2,2000)
        DO 400 J = 1,IYR
  400   WRITE (2,1000) ,NYR(J), (AVRF(J,K), K = 1,NVAL)
 1000   FORMAT (I8,15 F9.1)
 2000   FORMAT (10X,'MEAN AVERAGE CATCHMENT RAINFALL IN MM'//)
        STOP
        END
```

B. DESCRIPTION OF COMPUTER PROGRAMME CATCH.FOR

The computer programme CATCH.FOR is written in FORTRAN IV language and run on VAX-11/780 digital computer system. The programme computes the weighted average catchment rainfall using the Thiessen weights (or for that matter any weights) supplied by user. Some of the important variables used in the programme are described below:

VARIABLE	DESCRIPTION
NSTN	Number of Raingauge Stations(Max.20 stations)
IYR	Number of years (Upto 100 years)
NVAL	Number of values in an year upto 40 values are taken (Say ten daily or monthly values)
WT	Thiessen weights or any other user desired weights
NYR	Calendar year in four digits
RAIN(I,J,K)	Three dimensional array consisting of rainfall data of all stations for all the years for given number of values.
AVRF(J,K)..	Two dimensional array consisting of the average rainfall for each of the values for the years under consideration.

C. INPUT SPECIFICATIONS

The input data is read through an input data file CAT.DAT. Besides the number of stations, number of years, numbers of values and station weights, the input file also consists of the rainfall data for all values year-wise for a station. Rainfall data for the remaining sta-

INPUT DATA FILE

```
100   041413
200   ,41,35,10,14
300   1971 00,00 00,00 00,00 55,80 98,60 401,6 253,6 214,6 125,8 67,40 00,00 00,00 1217,4
400   1972 00,00 01,20 09,60 69,50 111,6 155,8 422,8 112,8 152,4 92,00 26,40 00,00 1144,1
500   1973 00,00 00,00 00,00 00,00 06,40 314,8 365,2 171,6 00,00 00,00 00,00 00,00 858,0
600   1974  0,00  0,00  3,6  38,4  195,1 137,0 360,0 216,3 126,4 143,4  0,00  0,00 1220,5
700   1975 00,00 00,00 00,00 02,60 123,8 695,1 467,4 201,9 262,2 143,6 77,60 00,00 1974,2
800   1976 00,00 00,00 00,00 108,8 00,00 193,5 449,2 192,7 142,7 00,20 116,6 00,00 1203,7
900   1977 00,00 00,00 00,00 64,00 71,20 297,3 489,6 137,2 126,1 103,8 105,0 00,00 1394,2
1000  1978 00,00 00,00 00,00 28,40 72,30 256,4 314,7 356,3 189,2 34,20 25,30 01,20 1278,0
1100  1979 00,00 10,00 00,00 11,20 76,00 268,8 186,2 442,4 192,2 93,20 88,30 00,00 1368,3
1200  1980 00,00 00,00 00,00 121,4 26,80 290,8 547,9 343,1 87,40 175,8 104,0 07,00 1704,2
1300  1981  0,00  0,00  1,1    90,0 112,9 212,5 324,3 212,8 281,8  26,8  20,3  0,00 1282,5
1400  1982  0,00  0,00  1,2    24,0 153,2  80,6 250,1 150,1  80,4 183,2  31,5  0,00  954,3
1500  1983  0,00  0,00  0,00  0,00  38,0 493,7 164,2 232,6  83,4  31,3  28,2  12,9 1084,3
1600  1984  0,00  40,0  28,6 111,2  14,6 123,5 351,3  77,0 174,3 128,8   1,9   1,2 1052,5
1700  1971 0,00 0,00 0,00 0,00 73,00 633,5 403,6 267,6 147,5 60,00 14,00 0,00 1599,2
1800  1972 0,00 0,00 0,00 17,70 51,30 464,3 842,0 204,2 182,3 66,80 16,00 0,00 1844,6
1900  1973 0,00 0,00 0,00 02,50 99,80 570,6 826,1 255,8 38,50 157,4 14,00 0,00 1964,7
2000  1974 0,00 0,00 02,50 35,50 151,7 198,2 921,2 527,8 181,4 146,9 0,00 0,00 2165,2
2100  1975 0,00 0,00 0,00 05,10 30,70 858,8 50,9 528,8 236,3 123,7 61,40 0,00 2345,7
2200  1976 0,00 0,00 27,70 53,90 0,00 410,8 766,6 322,1 149,2 70,60 92,80 0,00 1893,7
2300  1977 0,00 08,90 03,10 40,70 72,00 328,7 735,5 235,6 207,0 135,1 110,4 0,00 1877,0
2400  1978 0,00 05,00 0,00 22,00 74,80 528,8 435,6 436,4 109,9 129,0 32,30 0,00 1771,8
2500  1979  25,5  2,2   0,00  1,00 80,40 405,8 294,6 704,9 193,0  46,3 193,7 0,00 1947,4
2600  1980  0,0  0,00  0,00  66,0  27,1 680,6 752,4 601,6  65,2   4,1  39,3 20,8  2257,1
2700  1981  0,00  0,00  0,00  26,6  88,8 323,1 830,4 507,5 139,1  32,7 40,1   0,00 1988,3
2800  1982  0,00  0,00   0,5   8,3 137,4 276,5 843,6 290,2  57,8  71,6 12,2   0,00 1698,1
2900  1983  0,00  0,00  0,00  0,00  43,8 730,6 617,3 457,9 170,0  33,9 23,4   9,1  2086,0
3000  1984  16,8  1,9   13,9  24,3   7,7 519,2 685,3 263,9 127,3  57,4 0,00   0,2  1717,9
3100  1971   0,0   0,0   0,0  11,4  50,8 130,2  45,8  99,6  94,0 128,0   0,0   0,0 559,8
3200  1972   0,0   0,0  12,2  55,1  83,7  93,5 113,5  46,2  84,3 158,9  23,4   0,0 670,8
3300  1973   0,0   0,0   0,0   1,5  82,9 207,2 107,3  67,2  86,2 103,5   3,8   0,0 659,6
3400  1974   0,0   0,0   2,8  29,0  99,8  21,4 111,5  52,6 208,2 168,8   0,0   0,0 694,1
3500  1975   0,0   0,0   0,0  53,3 151,2  71,9 174,3  34,3 209,0 238,4  22,5   0,0 954,9
3600  1976   0,0   0,0  20,8  28,8  40,3 117,3  98,4  42,9  43,2  54,6  66,2   0,0 512,5
3700  1977   0,0   0,0  14,0  35,5 188,1  90,0  99,5  70,1  48,1  93,7  49,6   0,0 688,6
3800  1978   0,0   7,1   0,0  77,5  87,0  50,9  97,4 118,3 157,5 129,0  43,9   6,1 774,7
3900  1979  0,0   2,0   0,0  30,5  79,1  172,0 56,5  304,3 235,6  82,9  39,9  0,0 1002,8
4000  1980  0,0   0,0   0,0  99,1   6,0   95,0 177,0  96,5 181,6  69,6  51,0  8,2  784,8
4100  1981  0,0   0,0   0,0  13,8  41,0  137,6 295,8 106,1 222,5  36,2  61,4  0,0  914,4
4200  1982  0,0   0,0   0,0  13,1 148,2  71,2 161,1  55,7  63,5   30,7  19,4  0,0  562,9
4300  1983  0,0   0,0   0,0   0,0  19,2 304,3  91,9 138,7  67,7   19,6   2,1  17,8 661,3
4400  1984  0,0   0,7   8,4  47,2   0,0  52,2 141,4  29,3 153,6   88,8  0,0   0,0  521,6
4500  1971 00,00 00,00 00,00 73,30 107,0 49,40 20,20 111,7 88,70 72,90 00,00 00,00 523,2
4600  1972 00,00 00,00 01,30 19,40 29,70 34,40 37,40 14,90 108,1 103,4 03,50 00,00 352,1
4700  1973 00,00 00,00 00,00 12,50 17,60 68,20 52,50 63,80 46,70 172,8 06,60 00,00 440,7
4800  1974 00,00 00,00 14,70 16,90 30,50 29,00 44,80 28,30 266,5 116,1 00,00 00,00 546,8
4900  1975 00,00 04,10 05,10 02,00 76,80 59,80 97,00 13,10 281,6 121,0 06,10 00,00 666,6
5000  1976 00,00 00,00 19,40 20,60 00,00 73,70 36,60 11,30 49,10 16,70 36,10 00,00 263,5
5100  1977 00,00 00,00 34,20 49,00 166,0 81,10 52,30 13,30 12,40 81,60 85,10 00,00 575,0
5200  1978 00,00 00,50 00,00 47,40 65,20 18,30 46,20 33,50 257,3 92,30 31,10 15,20 607,0
5300  1979 16,8   0,00  0,00  0,00 78,10 141,8 148,6 197,1 200,0 61,10 57,90  0,00 901,4
5400  1980  0,00  0,00  0,00 50,70 42,20 56,10 70,20 70,20 123,4 13,00 24,90  4,00 454,6
5500  1981  12,0  0,00  0,00 11,30 43,30 134,5 87,10 40,20 212,3 26,20 87,10  0,00 654,0
5600  1982  0,00  0,00  0,00  0,00 63,30 102,1 65,20 26,60 53,40 107,0 62,50  0,00 480,1
5700  1983  0,00  0,00  0,00  0,00 77,00 224,5 18,40 67,90 28,80 18,20 17,50  9,40 461,7
5800  1984  0,00  64,0  9,20  27,0 15,60 14,80 70,00 27,30 70,00 29,70  0,00  0,00 327,6
```

tions is provided in a similar way one after another. A sample input is provided.

D. OUTPUT SPECIFICATIONS

The output data file CAT.OUT consists of the average rainfall for all the values yearwise as per the specifications given below:

REC No.	OUTPUT LIST	FORMAT	REMARKS
1.	NYR(J)	I8	Calendar year
2.	(AVRF(J,K) K=1,NVAL	15F8.1	Average catchment rainfall values for each year

Example

In the example whose sample input is provided the data of four stations for the years 1971-84 (14 years) has been used. There are 13 values in each year; data of twelve calendar months and the annual value. The Thiessen weights of the four stations are 0.41, 0.35, 0.10 and 0.14. The sample input provided could be better understood from the information given above.

OUTPUT FILE

MEAN AVERAGE CATCHMENT RAINFALL IN MM

1971	0.0	0.0	0.0	34.3	86.0	406.3	252.6	207.2	125.0	71.6	4.9	0.0	1188.1
1972	0.0	0.5	5.3	42.9	76.2	240.5	484.6	124.4	149.9	87.4	19.3	0.0	1231.1
1973	0.0	0.0	0.0	2.8	48.3	359.0	456.9	175.5	28.6	89.6	6.2	0.0	1167.1
1974	0.0	0.0	4.7	33.4	147.3	131.7	487.4	282.6	173.4	143.3	0.0	0.0	1404.2
1975	0.0	0.6	0.7	8.5	87.4	601.1	240.5	273.1	250.5	143.0	56.4	0.0	1819.2
1976	0.0	0.0	14.5	69.2	4.0	245.2	467.4	197.6	121.9	32.6	92.0	0.0	1244.5
1977	0.0	3.1	7.3	50.9	96.4	257.3	475.4	147.6	130.7	110.6	98.6	0.0	1377.9
1978	0.0	2.5	0.0	33.7	73.7	297.9	297.7	315.3	147.8	95.0	30.4	3.2	1306.6
1979	11.3	5.1	0.0	8.0	78.1	289.3	205.9	486.1	197.9	71.3	116.1	0.0	1469.1
1980	0.0	0.0	0.0	89.9	27.0	374.8	515.5	370.7	94.1	82.3	65.0	11.5	1630.8
1981	1.7	0.0	0.5	49.2	87.5	232.8	465.4	281.1	216.2	29.7	40.7	0.0	1404.7
1982	0.0	0.0	0.7	14.1	134.6	151.2	423.0	172.4	67.0	118.2	27.9	0.0	1109.1
1983	0.0	0.0	0.0	0.0	43.6	520.0	295.1	279.0	104.5	29.2	22.4	11.6	1305.4
1984	5.9	26.1	18.7	62.6	10.9	239.6	407.8	130.7	141.2	85.9	0.8	0.6	1130.8

APPENDIX- VIII

A. COMPUTER PROGRAMME ISO.FOR

```
C       THIS PROGRAMME COMPUTES THE AREAL AVERAGE
C       PRECIPITATION USING ISOHYETAL METHOD
C       N=NO. OF ISOHYETAL AREAS
C       HISO=VECTOR CONTAINING THE AREA AREA ENCLOSED
C       BETWEEN THE TWO ISOHYETS
C       R=VECTOR CONTAINING THE VALUES OF AVERAGE
C       PRECIPITATION(TO BE COMPUTED TAKING THE AVERAGE OF
C       TWO CONSECUTIVE ISOHYETS AND SUPLYING THE UPPER
C       AND LOWER LIMITS FOR AVERAGE PRECIPITATIONS)
        DIMENSION HISO(100),AEN(0:100),R(100),E(100)
        1,P(100),Q(100),D(100)
        OPEN(UNIT=1,FILE='ISO.DAT',STATUS='OLD')
        OPEN(UNIT=2,FILE='ISO.OUT',STATUS='NEW')
        READ(1,*)N
        READ(1,*)(HISO(I),I=1,N)
        READ(1,*)(AEN(I),I=1,N)
        READ(1,*)(R(I),I=1,N)
        WRITE(2,1)
1       FORMAT(30X,'ISOHYETAL METHOD')
        WRITE(2,2)
2       FORMAT(30X,16('_')///)
        A=0.0
        B=0.0
        AEN(0)=0.0
        DO 3 I=1,N
        E(I)=AEN(I)-AEN(I-1)
        P(I)=E(I)*R(I)
        B=B+P(I)
        Q(I)=B
        D(I)=Q(I)/AEN(I)
3       CONTINUE
        WRITE(2,4)
4       FORMAT(1X,'ISOHYET',2X,'AREA',2X,'NET AREA',2X,'AVG. PREC.',2X,
        1'PREC. VOL.',2X,'TOTAL PREC. VOL.',2X,'AVG. DEPTH')
        WRITE(2,5)
5       FORMAT(10X,'(SQ KM)',2X,'(SQ KM)',4X,'(MM)',8X,'(CU M)'
        1,9X,'CU M',9X,'(MM)')
        WRITE(2,6)
6       FORMAT(1X,7('_'),2X,4('_'),2X,8('_'),2X,10('_'),2X,10('_'),2X
        1,15('_'),2X,10('_')/)
        WRITE(2,7)(HISO(I),AEN(I),E(I),R(I),P(I),Q(I),D(I),I=1,N)
7       FORMAT(1X,F7.0,2X,F5.0,2X,F7.2,F10.1,2X,F10.1,F15.1,2X,F10.
        14)
        CLOSE(UNIT=1)
        CLOSE(UNIT=2)
        STOP
        END
```

B. DESCRIPTION OF COMPUTER PROGRAMME ISO.FOR

The computer programme ISO.FOR computes the variation of depth with area over the catchment using Iso - hyetal method. The programme is written in FORTRAN IV language and run on VAX-11/780 digital computer system. The main variables used in the programme are described below:

VARIABLE	DESCRIPTION
N	No. of Isohyetal areas
HISO	Vector containing the precipitation values associated with each Iso hyets
AEN	Vector containing the comulative area enclosed between the two iso hyets
R	Vector containing the average precipitation between the two consecutive isohyets except the first one to be supplied by the user based on the observations at precipitation stations of the neighbouring basin
E	Vector containing the net area enclosed between the two consecutive isohyets
P	Vector containing the precipitation volume between the two consecutive isohyets.
Q	Vector containing the cumulative values of precipitation volume
D	Vector containing the total areal average precipitation over the area enclosed by consecutive isohyets.

C. INPUT SPECIFICATIONS :

The input file ISO.DAT should contain the values for the following input lists in the specified format:

REC.No.	INPUT LISTS	FORMAT	REMARK
1.	N	FREE	
2.	(HISO(I),I=1,N)	FREE	
3.	(AEN(I),I=1,N)	FREE	
4.	(R(I),I=1,N)	FREE	

D. OUTPUT SPECIFICATIONS :

After running the programme ISO.FOR an output file ISO.OUT will be created on disk. This output file will have the values of the following output lists in the specified format:

REC.No.	OUTPUT LISTS	FORMAT	REMARK
1.	Nil	30X,'ISOHYETAL METHOD'	
2.	Nil	30X, 16 ('-')|||	
3.	Nil	IX,'ISOHYET', 2X, 'AREA',2X, 'NET AREA',2X,'AV6.PREC.',2X, 'PREC.VOL',2X,'TOTAL PREC.VOL', 2X, 'AV6.DEPTH'	
4.	Nil	10X,'(SQKM)', 2X,'(SQKM)',4X,'(MM)' 8X,'(CUM)',9X, 'CUM',9X,'(MM)'	
5.	Nil	1X, 7('-'),2X, 4('-'), 2X, 8('-') 2X,10('-'),2X, 10('-'), 2X,15('-'), 2X,10('-')|	

6. (HISO(I),AEN(I) 1X, F7.0, 2X, F5.0, 2X, F7.2, F10.1,
E(I), R(I),P(I) 2X, F10.1, F15.1, 2X, F10.4
Q(I),D(I),I=1,N)

E. EXAMPLE

Following a storm an a particular catchment an isohyetal map is drawn. The total area enclosed by the isohyets is given below. Calculate the variation of depth with area over the catchment.

Isohyet (mm)	100	75	50	25	25
Total area enclosed (sq km)	32	224	500	1005	1517

In the area enclosed by the 100 mm isohyet it will be assumed that the average depth is 110 mm. For the area outside dthe 25 mm isohyet it will be assumed that the average depth is 20 mm.

(a) Input :

For the above example the structure of the input file ISO.DAT would be as given below:

```
5
100     75      50      25      15
 32     224     500     1005    1517
110     87.50   62.50   37.50   20.00
```

(b) Output :

ISOHYETAL METHOD

ISOHYET	AREA (SQ KM)	NET AREA (SQ KM)	AVG. PREC. (MM)	PREC. VOL. (CU M)	TOTAL PREC. VOL. CU M	AVG. (MM
100.	32.	32.00	110.0	3520.0	3520.0	110.0000
75.	224.	192.00	87.5	16800.0	20320.0	90.7143
50.	500.	276.00	62.5	17250.0	37570.0	75.1400
25.	1005.	505.00	37.5	18937.5	56507.5	56.2264
15.	1517.	512.00	20.0	10240.0	66747.5	43.9997

APPENDIX - IX

A. COMPUTER PROGRAMME DAILY.FOR

```
C       THIS PROGRAMME DISTRIBUTES THE DAILY RAINFALL INTO HOURLY
C       RAINFALL AS PER THE CHOICE OF THE S.R.R.G. AND COMPUTES
C       THE AVERAGE HOURLY RAINFALL
        DIMENSION RORG(50),RSRRG(24,50),WTONS(50),SUM1(24),CHO(50)
        1,S(50),RAIN(24,50)
        OPEN(UNIT=1,FILE='DAILY.DAT',STATUS='OLD')
        OPEN(UNIT=2,FILE='DAILY.OUT',STATUS='NEW')
C       NDAY=NO. OF DAYS
C       NORG=NO. OF O.R.G. STATIONS
C       NSRRG=NO. OF S.R.R.G STATIONS
C       WTONS=VECTOR CONTAINING WEIGHTS OF S.R.R.G. AND O.R.G. STATIONS
C       CHO=VECTOR CONTAINING CHOICE OF S.R.R.G FOR EACH O.R.G.
        READ(1,*)NDAY
        WRITE(2,20)
20      FORMAT(30X,'DAILY TO HOURLY CONVERSION OF RAINFALL AND COMPUTATIO
        1 OF AVERAGE HOURLY RAINFALL')
        WRITE(2,21)
21      FORMAT(10X,120('-'))
        DO 1 I=1,NDAY
        READ(1,*)NSRRG
        READ(1,*)NORG
        NTONS=NORG+NSRRG
        READ(1,*)(WTONS(J),J=1,NTONS)
        READ(1,*)(CHO(J),J=1,NORG)
C       RORG=VECTOR CONTAINING ORG STATIONS RAINFALL FOR THE DAY
        READ(1,*)(RORG(J),J=1,NORG)
C       RSRRG=VECTOR CONTAINING RAINFALL AT EACH S.R.R.G. STATIONS
        READ(1,*)((RSRRG(J,K),J=1,24),K=1,NSRRG)
        DO 2 J=1,NSRRG
        S(J)=0.0
        DO 3 K=1,24
        S(J)=S(J)+RSRRG(K,J)
3       CONTINUE
2       CONTINUE
        DO 4 J=1,24
        DO 5 K=1,NORG
        K1=CHO(K)
        RAIN(J,K)=RORG(K)*RSRRG(J,K1)/S(K1)
5       CONTINUE
4       CONTINUE
        DO 6 J=1,24
        L1=0
        L2=NORG+1
        DO 7 K=L2,NTONS
        L1=L1+1
        RAIN(J,K)=RSRRG(J,L1)
7       CONTINUE
6       CONTINUE
        DO 8 J=1,24
        SUM1(J)=0.0
```

```
      DO 9 K=1,NTONS
      SUM1(J)=SUM1(J)+RAIN(J,K)*WTONS(K)
9     CONTINUE
8     CONTINUE
      WRITE(2,12)I
12    FORMAT(4X,'ORG ST.NO.',10X,'RAINFALL OBS. FOR THE DAY(MM)
     1:--',I5)
      WRITE(2,14)(J,RORG(J),J=1,NORG)
14    FORMAT(10X,I4,10X,F15.2)
      DO 15 K=1,NSRRG
      WRITE(2,16) K
16    FORMAT(30X,'RAINFALL OBSERVED AT ',I3,'S.R.R.G. STATIONS(MM)')
      WRITE(2,11)(RSRRG(J,K),J=1,24)
15    CONTINUE
      WRITE(2,23)
23    FORMAT(10X,'THIESSEN WEIGHTS OF ALL THE STATIONS (O.R.G+S.R.R.G)')
      WRITE(2,24)(WTONS(J),J=1,NTONS)
24    FORMAT(4X,10F12.4)
      WRITE(2,10) I
10    FORMAT(30X,'AVERAGE RAINFALL FOR THE DAY(MM):---',I5)
      WRITE(2,11)(SUM1(J),J=1,24)
11    FORMAT(4X,10F12.4)
1     CONTINUE
      STOP
      END
```

B. DESCRIPTION OF COMPUTER PROGRAMME DAILY.FOR

This programme converts the daily rainfall data of OR.G. Stations into hourly rainfall data in the ratio of the hourly rainfall values of an appropriate S.R.R.G. station for the day. The choice of the S.R.R.G. stations for each O.R.G. station has to be made by the user. Further more the programme computes the average hourly rainfall values in the catchment during the storm using Theissen polygan method. The programme is written in FORTRAN-IV language and run on VAX-11/780 digital computer system. The main variables used in the programme are described below:

VARIABLE	DESCRIPTION
NDAY	No. of days
NSRRG	No. of operational SRRG for the day
NORG	No. of operational ORG for the day
WTONS	Vector containing the Theissen Weights for all the operational raingauge stations (ORG + SRRG)
CHO	Vector containing the SRRG No. of chosen for different ORG station for the distribution of daily rainfall
RORG	Vector containing the ORG stations rainfall for the day
RSRRG	Two dimensional array containing 24 values of hourly rainfall at each SRRG stations for the day
SUMI	Vector containing 24 values of average hourly rainfall for the day

C. INPUT SPECIFICATIONS

The input file DAILY.DAT should contain the values for the following input lists in the specified format.

REC.No.	INPUT LISTS	FORMAT	REMARK
1	NDAY	FREE	
2	NSRRG	FREE	
3	NORG	FREE	
4	(WTONS(J1,J=1, NTONS)	FREE	
5	(CHO(J),J=1, NORG)	FREE	
6	(RORG(J),J=1, NORG)	FREE	
7	((RSRRG(J,K),J=1, 24), K=1, NSRRG)	FREE	

D. OUTPUR SPECIFICATIONS

After successful running of the programme DAILY.FOR an output file DAILY.OUT will be ereated. This file will have the values of the following output lists including some no list parameters in the specified parameters.

REC.No.	OUTPUT LISTS	FORMAT	REMARK
1	Nil	30X,'DAILY TO HOURLY CONVERSION OF RAINFALL AND COMPUTATION OF AVERAGE HOURLY RAINFALL'	
2	Nil	10X, 120('-')	
3	I	4X,'ORGST.No.',10X,'RAINFALL OBS.FOR THE DAY(MM):--',I5	
4	(J,RORG(J),J=1, NORG)	10X, I4, 10X, F15.2	

5	K	30X,'RAINFALL OBSERVED AT', I3,'SRRG STATIONS (MM)'
6	(RSRRG(J,K),J=1 24)	4X, 10F12.4
7	Nil	10X,'THEISSEN WEIGHTS OF ALL THE STATIONS (O.R.G.+S.R.R.G)'
8	(WTONS(J),J=1 NTONS)	4X, 10F12.4
9	I	30X,'AVERAGE RAINFALL FOR THE DAY (MM): ---',I5
10	(SUMI(J),J=1,24)	4X, 10F12.4

E. EXAMPLE

During a storm the following rainfall values were observed on a day at five O.R.G. stations:

O.R.G. Station No.	Rainfall (mm)
1	65.3
2	23.2
3	171.0
4	42.0
5	30.4

Two S.R.R.G. were recording the rainfall on that day the recorded hourly rainfall values for the two S.R.R.G. are given below:

Hourly rainfall data of S.R.R.G. No.1

0 0 0 0 0 0 0 0 0 0 25.7 0 0.1 1.0 6.0 1.3 0.0 0.0 0.305 0.1 1.0 24.4 0.2

Hourly rainfall data of S.R.R.G. No. 2

0 0 0 0 0 0 0 0 0.2 2.1 0.7 0.3 0.1 0.1 4.7 0.0 0 0 0 0 0
0 1.7 9.0

Mass curve analysis was performed for the recorded rainfall of each station. The mass curves of daily rainfall for O.R.G. stations were compared with that of the hourly rainfall for S.R.R.G. stations and the following choice of S.R.R.G. stations was made for different O.R.G. stations:

O.R.G. Station No.	1	2	3	4	5
Chosen S.R.R.G. Station No.	1	2	1	2	1

Theissen Weights for all the raingauge stations are 0.1, 0.2, 0.15, 0.15, 0.10, 0.15 and 0.15 respectively. Here first five values of Theissen Weights correspond to O.R.G. stations while the remaining two to S.R.R.G. stations.

Find out the average hourly rainfall in the catchment on the day.

(a) Input :

For the above example the structure of the input file DAILY.DAT would be as follows:

```
1
2
5
0.1  0.2  0.15  0.15  0.10  0.15  0.15
1  2  1  2  1
65.3  23.2  171.0  42.0  30.4
0 0 0 0 0 0 0 0 0 0 25.7 0 0.1 1.0 6.0 1.3 0.0 0.0
0.3 0.5 0.1 1.0 24.4 0.2
0 0 0 0 0 0 0 0 0.2 2.1 0.7 0.3 0.1 0.7 0.3 0.1 0.1 4.7 0.0
0 0 0 0 0 0 1.7 9.0
```

(b) <u>Output</u> :

```
                   DAILY TO HOURLY CONVERSION OF RAINFALL AND COMPUTATION OF AVERAGE HOURLY RAINFALL
-------------------------------------------------------------------------------------------------------------------
ORG ST.NO.         RAINFALL OBS. FOR THE DAY(MM):--    1
     1                   65.30
     2                   23.20
     3                  171.00
     4                   42.00
     5                   30.40
                       RAINFALL OBSERVED AT   1S.R.R.G. STATIONS(MM)
   0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
  25.7000     0.0000     0.1000     1.0000     6.0000     1.3000     0.0000     0.0000     0.3000     0.5000
   0.1000     1.0000    24.4000     0.2000
                       RAINFALL OBSERVED AT   2S.R.R.G. STATIONS(MM)
   0.0C00     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.2000     2.1000
   0.7000     0.3000     0.1000     0.1000     4.7000     0.0000     0.0000     0.0000     0.0000     0.0000
   0.0000     0.0000     1.7000     9.0000
   THIESSEN WEIGHTS OF ALL THE STATIONS (O.R.G+S.R.R.G)
   0.1000     0.2000     0.1500     0.1500     0.1000     0.1[illegible]     0.1500
                       AVERAGE RAINFALL FOR THE DAY(MM):---    1
   0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.1458     1.5306
  19.3017     0.2187     0.1460     0.8041     7.8127     0.9505     0.0000     0.0000     0.2194     0.3656
   0.0731     0.7312    19.0800     6.7058
```