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# SOFTWARE FOR ENGINEERING WORKSTATIONS

## MICROSOFTWARE FOR ENGINEERS

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# Regional confidence intervals for floods

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A problem arising in the use of regionalized data for the estimation of the effects of future urbanization on a catchment is to construct confidence intervals for estimates of peak discharge for various durations. This discharge is modeled by a log Pearson III distribution in which both the skew and standard deviation are obtained from a pool of regional data and so are known to a much higher accuracy than the mean. Confidence intervals for this situation and a computer program which computes them are discussed.

Key Words: *T*-year flood, confidence interval, log Pearson III distribution, regionalization, urbanization.

## INTRODUCTION

In predicting catchment response – peak discharge and peak discharge for various durations – it is standard to use a log Pearson III distribution with a regional estimate for skew[1,2]. An important source of uncertainty in *T*-year estimates for these discharges is caused by the uncertainty in the estimates of the parameters of the log Pearson III distribution. This uncertainty can be quantified by the use of confidence intervals for the *T*-year values. In Refs 3 and 4 it is shown how to accurately compute such confidence intervals; see the references given there, especially Stedinger[5].

In following the guidelines of Refs 1 and 2, the skew coefficient is estimated either from a map of regional skews or from a large pool of data from that region. This makes the error in estimating the skew of an entirely different type, and presumably much smaller, than the error in estimating the mean and standard deviation from the data at the gate station. What is usually done to simplify this complicated situation, and what is done in Whitley[3], is to suppose that the skew is given exactly, and therefore that the confidence intervals come from the estimation of the mean and standard deviation.

In a recent study[6], data from several gage stations were combined in order to be able to obtain estimates for the effects of proposed urbanization at a given site. This regionalization was done to give a more stable estimate of the excess discharges caused by the urbanization, for which mitigation measures are to be taken. This study[6] suggests the use of regional estimates for the skew *and* for the standard deviation, these values applying to the discharges for all the durations. This situation is modeled below by regarding both the skew and standard deviation as known. In this case the distribution for *T*-year values will be less spread out than in the case considered in Whitley[3] in which only the skew is known. Obtaining confidence intervals for *T*-year values for each of the gage stations in McCuen[6] is to be discussed below.

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## MATHEMATICAL DISCUSSION

The procedure of McCuen[6] will be modeled as follows: a regional skew $\gamma$ and a regional standard deviation $\sigma$ will be given, and, because they have been estimated from a large pool of regional data, will be supposed to be known exactly, i.e. with much less variation than occurs in the estimate for the station means for various durations.

For a given duration, the peak discharge is assumed to have a logarithm $X$ which has a Pearson III distribution. For a given $T$-year return period we want the $T$-year value of $X$, i.e. with $p=1-1/T$, we want to find the $p$th quantile $y_p$ of the distribution of $X$ for which

$$P(X \leqq y_p)=p \qquad (1)$$

*A. Zero skew*

The case of zero skew is the simplest and the derivation below will be done in a way which will readily extend to the case of nonzero skew. First, then, suppose that $X$ has a normal distribution with unknown mean $\mu$ and known standard deviation $\sigma$, a $N(\mu, \sigma)$ distribution. From (1),

$$P((X-\mu)/\sigma \leqq (y_p-\mu)/\sigma)=p$$

from which

$$(y_p-\mu)/\sigma=z_p \qquad (2)$$

where $z_p$ is the $p$th quantile for $(X-\mu)/\sigma$, a normal distribution with mean zero and standard deviation one.

This suggests the estimate

$$\hat{y}_p=\hat{\mu}+\sigma z_p \qquad (3)$$

Then

$$\frac{\hat{y}_p - y_p}{\sigma} = \frac{\hat{\mu} - \mu}{\sigma} \quad (4)$$

The estimator $\hat{\mu}$ involves a sample of $m$ record years of data, each of which has a distribution $X_i$ which is the same as the distribution of $X$ and is an independent sample of $X$, $i=1, \ldots, m$. Then

$$\frac{\hat{\mu}-\mu}{\sigma} = \left\{(1/m) \sum_{i=1}^{m} X_i - \mu\right\} \Big/ \sigma = (1/m) \sum_{i=1}^{m} \{(X_i - \mu)/\sigma\} \quad (5)$$

Each $(X_i - \mu)/\sigma$ has a $N(0, 1)$ distribution, and equation (5) is therefore distributed as $(1/m)N(0, m) = (1/\sqrt{m})N(0, 1)$.

Suppose that a confidence level $q$, $0<q<1$, is given. For this confidence level we want an estimator $e_q$ for which

$$y_p \leqq \hat{e}_q \text{ with probability } q \quad (6)$$

The interpretation of the statement in equation (6) is that the method of estimation $\hat{e}_q$ is a random variable whose distribution reflects the act of repeatedly applying the estimator to samples of size $m$ under the given hypotheses; i.e. if this method of estimation is applied to a large number of catchments, then we expect to have the inequality (6) hold for about $100q\%$ of the catchments.

From equations (4) and (5), if $t_{1-q}$ is a $1-q$ percentile for a $N(0, 1)$ random variable $Z$, which is to say that

$$P(Z \leqq t_{1-q}) = 1 - q$$

then

$$\frac{\hat{y}_p - y_p}{\sigma} \geqq \frac{t_{1-q}}{\sqrt{m}}$$

holds with probability $q$. Therefore

$$y_p \leqq \hat{\mu} + \sigma z_p - \sigma t_{1-q}/\sqrt{m} \quad (7)$$

also holds with probability $q$, and equation (7) provides a $100q\%$ confidence interval for $y_p$.

*B. Nonzero skew*

In the case of skew $\gamma \neq 0$, the logarithm $X$ of discharges has a Pearson III distribution with density function

$$f(x) = \frac{[(x-c)/a]^{b-1}}{|a|\Gamma(b)} e^{-[(x-a)/c]} \quad (8)$$

where $b>0$, and in the case of positive $a$ the density is given by equation (8) for $x>c$ and is zero for $x<c$, while in the case of negative $a$ the density is given by equation (8) for $x<c$ and is zero for $x>c$. Computing the mean $\mu$, standard deviation $\sigma$, and skew $\gamma$ from equation (8) shows that

$$\sigma^2 = a^2 b$$
$$\gamma^2 = 4/b \quad (9)$$
$$\mu = c + ab$$

where $a$ has the same sign as $\gamma$ (see, for example, Ref. 7.)

The form of the density in equation (8) shows that $(X-c)/a$ has the density

$$g(x) = \frac{1}{\Gamma(b)} x^{b-1} e^{-x}$$

for $x>0$, and 0 for $x<0$, which is the density of a gamma distribution $\Gamma(b, 1)$ with shape parameter $b$ and scale parameter 1.

First consider the case where $a<0$, i.e. the case of negative skew. Since

$$1-p = P(X \geqq y_p) = P((X-c)/a \leqq (y_p - c)/a) \quad (10)$$

(using $a<0$), then

$$(y_p - c)/a = z_{1-p}$$

where $z_{1-p}$ is the $1-p$th quantile for a $\Gamma(b, 1)$ distribution. With the estimate

$$\hat{y}_p = \hat{\mu} - ab + az_{1-p} \quad (11)$$

$$\frac{\hat{y}_p - y_p}{a} = \frac{\hat{\mu} - \mu}{a} \quad (12)$$

As in part A, the estimator $\hat{\mu}$ is for $m$ record years of data, each of which has a distribution $X_i$ which is the same as the Pearson III distribution of $X$ and is an independent sample of $X$, $i=1, \ldots, m$. Then

$$\frac{\hat{\mu}-\mu}{a} = \left\{(1/m) \sum_{=1}^{m} X_i - \mu\right\} \Big/ a = (1/m) \sum_{i=1}^{m} \{(X_i - c)/a\} - b \quad (13)$$

Each $(X_i - \mu)/\sigma$ has a $\Gamma(b, 1)$ distribution, and equation (5) is therefore distributed as $(1/m)\Gamma(mb, 1) - b$ [Ref 8, page 277].

Given $q$, if $t_q$ is a $q$th quantile for $\Gamma(mb, 1)$, then

$$\frac{\hat{\mu}-\mu}{a} \leqq (t_q/m) - b$$

holds with probability $q$. Then

$$y_p \leqq \hat{\mu} + az_{1-p} - at_q/m \qquad (\text{for skew} < 0) \quad (14)$$

A similar argument for the case $a>0$ gives

$$y_p \leqq \hat{\mu} + az_p - at_{1-q}/m \qquad (\text{for skew} > 0) \quad (15)$$

where $z_p$ is the $p$th quantile for a $\Gamma(b, 1)$ distribution and $t_{1-q}$ is the $1-q$th quantile for a $\Gamma(mb, 1)$ distribution.

## PROGRAMMING DISCUSSION

The form of the confidence intervals in equations (7), (14), and (15) is

$$y_p \leqq \hat{\mu} + B(p, q) \quad (16)$$

where $B$ depends on the given skew $\gamma$, standard deviation $\sigma$, the number of years of record $m$, the $T$-year value $T$, for which $p=1-1/T$, and the confidence level $q$. The program muonly, whose listing is given at the conclusion of this paper, asks for input values for $m$, $\gamma$, and $\sigma$; and for these it computes the values of $B(p, q)$ for $T=2, 5, 10, 25, 50, 100$, and 200 years and $q=0.15, 0.50, 0.85$, and 0.95 from the appropriate formula depending on the sign of $\gamma$.

In the case of zero skew, the values $z_p$ and $t_{1-q}$ are computed in the function normal(s) by table lookup. In the case of nonzero skew, the values $z_{1-p}$ and $t_q$ of equation (14), or $z_p$ and $t_{1-q}$ of equation (15), are computed in the function WH$(b, x)$ by applying the Wilson–Hilferty transformation to the corresponding values for a normal distribution; for references to this approximation see Refs 8, 9, and 10. From these values $B(p, q)$ is computed.

Because of the form of equation (16), the discharge values (whose log base 10 values are the values of $X$ and which are averaged to obtain $\hat{\mu}$) are given in cfs by

$$10^{\hat{\mu}}10^{B(p,q)} \quad (17)$$

In the program, input is requested of sample log means for the durations: Instantaneous = Peak $Q$, 5, 15, and 30 minutes, and 1, 2, 3, 6, 12, and 24 hours. An input value of $\hat{\mu}=3$ will give as output $10^3$ times the matrix $10^{B(p,q)}$ from which all the other duration values are obtained simply by the multiplication indicated by equation (17).

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## APPENDIX A: EXAMPLE APPLICATION

```
Catchment Name:  test
Number of record years =   4Ø
Regional skew =  -Ø.3ØØ
Regional standard  deviation =  Ø.21Ø

Discharge below given in cfs



Instantaneous Qpeak
  mean (log base 1Ø) =   3.ØØØØØ
percent confidence:
                  15%              5Ø%              85%              95%

T=  2             946.            1Ø24.            11Ø9.            1163.
T=  5            1395.            15Ø9.            1635.            1714.
T= 1Ø            1687.            1825.            1976.            2Ø72.
T= 25            2Ø45.            2212.            2396.            2513.
T= 5Ø            23Ø4.            2493.            27ØØ.            2831.
T=1ØØ            2557.            2766.            2996.            3142.
T=2ØØ            28Ø4.            3Ø33.            3286.            3446.


Catchment Name:  rubio
Number of record years =   41
Regional skew =  -Ø.3ØØ
Regional standard  deviation =  Ø.21Ø

Discharge below given in cfs
```

Instantaneous Qpeak
mean (log base 1Ø) = 3.26943
percent confidence:

| | 15% | 5Ø% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 1762. | 19Ø4. | 2Ø6Ø. | 2159. |
| T= 5 | 2597: | 28Ø7. | 3Ø37. | 3183. |
| T= 1Ø | 314Ø. | 3393. | 3672. | 3848. |
| T= 25 | 38Ø7. | 4114. | 4452. | 4666. |
| T= 5Ø | 429Ø. | 4636. | 5Ø16. | 5257. |
| T=1ØØ | 4759. | 5144. | 5566. | 5833. |
| T=2ØØ | 522Ø. | 5641. | 61Ø4. | 6397. |

5-Minute duration
mean (log base 1Ø) = 3.25432
percent confidence:

| | 15% | 5Ø% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 17Ø1. | 1839. | 199Ø. | 2Ø85. |
| T= 5 | 25Ø8. | 2711. | 2933. | 3Ø74. |
| T= 1Ø | 3Ø32. | 3277. | 3546. | 3716. |
| T= 25 | 3677. | 3974. | 43ØØ. | 45Ø6. |
| T= 5Ø | 4143. | 4477. | 4845. | 5Ø77. |
| T=1ØØ | 4597. | 4968. | 5375. | 5634. |
| T=2ØØ | 5Ø41. | 5448. | 5896. | 6179. |

15-Minute duration
mean (log base 1Ø) = 3.23142
percent confidence:

| | 15% | 5Ø% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 1614. | 1744. | 1888. | 1978. |
| T= 5 | 2379. | 2571. | 2783. | 2916. |
| T= 1Ø | 2877. | 31Ø9. | 3364. | 3525. |
| T= 25 | 3488. | 377Ø. | 4Ø79. | 4275. |
| T= 5Ø | 393Ø. | 4247. | 4596. | 4817. |
| T=1ØØ | 4361. | 4713. | 5Ø99. | 5344. |
| T=2ØØ | 4782. | 5168. | 5593. | 5861. |

3Ø-Minute duration
mean (log base 1Ø) = 3.19863
percent confidence:

| | 15% | 5Ø% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 1497. | 1618. | 175Ø. | 1834. |
| T= 5 | 22Ø6. | 2384. | 258Ø. | 27Ø4. |
| T= 1Ø | 2667. | 2883. | 3119. | 3269. |
| T= 25 | 3234. | 3495. | 3782. | 3964. |
| T= 5Ø | 3644. | 3938. | 4262. | 4466. |
| T=1ØØ | 4Ø43. | 437Ø. | 4729. | 4956. |
| T=2ØØ | 4435. | 4793. | 5186. | 5435. |

1-Hour duration
mean (log base 1Ø) = 3.129Ø8
percent confidence:

| | 15% | 5Ø% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 1275. | 1378. | 1491. | 1563. |
| T= 5 | 188Ø. | 2Ø32. | 2198. | 23Ø4. |
| T= 1Ø | 2273. | 2456. | 2658. | 2785. |
| T= 25 | 2756. | 2978. | 3223. | 3377. |
| T= 5Ø | 31Ø5. | 3356. | 3631. | 38Ø5. |
| T=1ØØ | 3445. | 3723. | 4Ø29. | 4222. |
| T=2ØØ | 3778. | 4Ø83. | 4419. | 4631. |

2-Hour duration
mean (log base 10) = 3.02734
percent confidence:

| | 15% | 50% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 1009. | 1090. | 1180. | 1236. |
| T= 5 | 1487. | 1607. | 1739. | 1823. |
| T= 10 | 1798. | 1943. | 2103. | 2204. |
| T= 25 | 2180. | 2356. | 2550. | 2672. |
| T= 50 | 2457. | 2655. | 2873. | 3011. |
| T=100 | 2726. | 2946. | 3187. | 3340. |
| T=200 | 2989. | 3231. | 3496. | 3664. |

3-Hour duration
mean (log base 10) = 2.95619
percent confidence:

| | 15% | 50% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 856. | 926. | 1002. | 1050. |
| T= 5 | 1263. | 1364. | 1476. | 1547. |
| T= 10 | 1526. | 1650. | 1785. | 1871. |
| T= 25 | 1851. | 2000. | 2164. | 2268. |
| T= 50 | 2085. | 2254. | 2439. | 2556. |
| T=100 | 2314. | 2500. | 2706. | 2836. |
| T=200 | 2538. | 2742. | 2968. | 3110. |

6-Hour duration
mean (log base 10) = 2.79173
percent confidence:

| | 15% | 50% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 586. | 634. | 686. | 719. |
| T= 5 | 865. | 934. | 1011. | 1060. |
| T= 10 | 1045. | 1130. | 1222. | 1281. |
| T= 25 | 1267. | 1370. | 1482. | 1553. |
| T= 50 | 1428. | 1543. | 1670. | 1750. |
| T=100 | 1584. | 1712. | 1853. | 1942. |
| T=200 | 1738. | 1878. | 2032. | 2130. |

12-Hour duration
mean (log base 10) = 2.60975
percent confidence:

| | 15% | 50% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 386. | 417. | 451. | 473. |
| T= 5 | 569. | 614. | 665. | 697. |
| T= 10 | 687. | 743. | 804. | 842. |
| T= 25 | 833. | 901. | 975. | 1022. |
| T= 50 | 939. | 1015. | 1098. | 1151. |
| T=100 | 1042. | 1126. | 1219. | 1277. |
| T=200 | 1143. | 1235. | 1336. | 1401. |

24-Hour duration
mean (log base 10) = 2.38669
percent confidence:

| | 15% | 50% | 85% | 95% |
|---|---|---|---|---|
| T= 2 | 231. | 249. | 270. | 283. |
| T= 5 | 340. | 368. | 398. | 417. |
| T= 10 | 411. | 444. | 481. | 504. |
| T= 25 | 499. | 539. | 583. | 611. |
| T= 50 | 562. | 607. | 657. | 689. |
| T=100 | 623. | 674. | 729. | 764. |
| T=200 | 684. | 739. | 800. | 838. |

```
      program muonly

c     Robert Whitley, Dept. of Math., Univ. of CA, Irvine, CA 92717
c     T.V. Hromadka II, Williamson and Schmidt, 17782 Sky Park Blvd.,
c     Irvine, Ca 92714
c
c     This program calculates 15%,50%,85%,and 95% confidence intervals
c     for return periods T=2,5,10,25,50,100, and 200 years for input
c     values for the mean of log base 10 values for the durations:
c     Instantaneous, 5 min., 15 min., 30 min., 1 hr., 2 hr., 3 hr.,
c     6 hr., 12 hr., and 24 hr. The distribution of values is modelled
c     by a log Pearson III distribution where the skew and the standard
c     deviation are given by regional data, and the entire statistical
c     variation is asumed to come from the variation in the sample mean.
c     The confidence intervals for the log data have the form
c     (sample mean +B(p,q)), where B(p,q) is a function of the number of
c     years of record, the regional skew, the regional standard
c     deviation, p=1-1/T, and confidence level q. Consequently the
c     discharge values for a given sample mean are just 10 to the power
c     (sample mean) times 10 to the power B(p,q).

      external C
      real B(7,4),C,p(7),q(4),sigma,skew
      integer i,j,m
      character*20 name

      print *, "catchment name = ?  "
      read *, name
      print *, "number of years of record = ?  "
      read *, m
      print *, "regional skew for log base 10 data = ?  "
      read *, skew
      if (abs(skew) .le. .05) print *, "Using zero skew"
      print *, "regional standard deviation for log base 10 data = ?  "
      read *, sigma

c     percentiles q for confidence intervals
      q(1)=.15
      q(2)=.50
      q(3)=.85
      q(4)=.95

c     values for T year floods, T=2,5,10,25,50,100,200, p=1-1/T
      p(1)=.50
      p(2)=.80
      p(3)=.90
      p(4)=.96
      p(5)=.98
      p(6)=.99
      p(7)=.995

      do 20 i=1,7
           do 10 j=1,4
                B(i,j)=C(m,skew,sigma,p(i),q(j))
   10 continue
   20 continue

c     For any given return frequency T with the associated value p=1-1/T
c     and a confidence level q, the corresponding one sided confidence
c     interval has left endpoint B(i,j)+the estimated mean for the site.
```

```
c     These are computed and printed out below for various values for
c     the means.

      call printhead(m,name,sigma,skew)
      call printdata(B)

      end
c     program end

      real function normal(s)

c     Uses table lookup to return the value t such that for Z a N(Ø,1)
c     random variable, P(Z<t)=s

      real s,small

      small=.ØØØ5
      if (abs(s-.Ø5) .le. small) then
           normal=-1.64485
      else if (abs(s-.15) .le. small) then
           normal=-1.Ø3643
      else if (abs(s-.5Ø) .le. small) then
           normal=.Ø
      else if(abs(s-.8Ø) .le. small ) then
           normal=.84162
      else if(abs(s-.85) .le. small ) then
           normal=1.Ø3643
      else if(abs(s-.9Ø) .le. small ) then
           normal=1.28155
      else if(abs(s-.95) .le. small ) then
           normal=1.64485
      else if(abs(s-.96) .le. small ) then
           normal=1.75Ø69
      else if(abs(s-.98) .le. small ) then
           normal=2.Ø5375
      else if(abs(s-.99) .le. small ) then
           normal=2.32635
      else if(abs(s-.995) .le. small ) then
           normal=2.57583
      else
           print *,"normal percentile not in table"
           stop
      endif
      return
      end

      real function WH(b,x)
c     Uses the Wilson-Hilferty approximation in order to compute the
c     x-th percentile for the distribution Gamma(b,1); if Y has such a
c     distribution, then WH(b,x)=t is a value with, approximately,
c     Pr(Y<t)=x. See Kendall and Stuart, The Advanced Theory of
c     Statistics, Vol. I, page 4ØØ and see Mathur, A Note on Wilson-
c     Hilferty Transformation of Chi-squared, Bull. of the Calcutta
c     Stat. Assoc. 1Ø(1961) 1Ø3-1Ø5 for a discussion of the error.

      real b,temp,x

      temp=1-(1/(9*b))+x*sqrt(1/(9*b))
      temp=exp(3*log(temp))
      WH=b*temp

      return
      end
```

```
      real function C(m,skew,sigma,pp,qq)

c     For a given confidence level pp and T year value qq, returns a
c     value C so that C plus the estimated mean is the left end point of
c     the 100 pp % confidence interval for the return frequency
c     qq=1-1/T.

      real a,b,normal,pp,qq,skew,sigma,small,WH
      external normal,WH
      integer m

      small = .05

      if (abs(skew) .le. small) then
           C=sigma*normal(pp)-sigma*(-normal(qq))/sqrt(m)
      endif

      if (skew .gt. small) then
           b=4/(skew*skew)
           a=sigma/sqrt(b)
           C=a*WH(b,normal(pp))-a*WH(m*b,-normal(qq))/m
      endif

      if (skew .lt. -small) then
           b=4/(skew*skew)
           a=-sigma/sqrt(b)
           C=a*WH(b,-normal(pp))-a*WH(m*b,normal(qq))/m
      endif
      return
      end

      subroutine printhead(m,name,sigma,skew)
c     prints a heading for the output for the catchment "name"

      character*20 name
      integer m
      real sigma,skew

      open(unit=2, file='prn')
      write(2,10) name
   10 format(1x,"Catchment Name:   ",A)
      write(2,20) m,skew,sigma
   20 format(1x,"Number of record years =   ",I3/
     &       1x,"Regional skew =   ",F6.3/
     &       1x,"Regional standard  deviation =   ",F5.3/)
      write(2,30)
   30 format(1x,"Discharge below given in cfs")
      close(unit=2,file='prn')
      return
      end

      subroutine printdata(B)
c     print for a given mean of log base 10, a matrix of confidence
c     levels in cfs

      integer i,j,k,T(7)
      real B(7,4),mean,tprint(4)

      character*20 Dur(10)

      T(1)=2
      T(2)=5
      T(3)=10
      T(4)=25
```

```
   T(5)=5Ø
   T(6)=1ØØ
   T(7)=2ØØ

   Dur(1)="Instantaneous Qpeak"
   Dur(2)="5-Minute duration"
   Dur(3)="15-Minute duration"
   Dur(4)="3Ø-Minute duration"
   Dur(5)="1-Hour duration"
   Dur(6)="2-Hour duration"
   Dur(7)="3-Hour duration"
   Dur(8)="6-Hour duration"
   Dur(9)="12-Hour duration"
   Dur(1Ø)="24-Hour duration"

   open(unit=2, file='prn')
   do 6Ø k=1,1Ø
   write(*,2) Dur(k)
 2 format(1x,A)
   print *,"mean for log base 1Ø data = ?  "
   read *,mean
   write(2,7)
7  format(1x,/)
   write(2,5) Dur(k)
 5 format(1x,A)
   write(2,1Ø) mean
1Ø format(1x,"  mean (log base 1Ø) =   ",F8.5)
   write(2,2Ø)
2Ø format(1x,"percent confidence:"/,2Øx,"15%",14x,"5Ø%",14x,
  &          "85%",14x,"95%"/)
   do 5Ø i=1,7
        do 3Ø j=1,4
             tprint(j)=mean+B(i,j)
             tprint(j)=exp(log(1Ø)*tprint(j))
3Ø      continue
        write(2,4Ø) T(i),tprint(1),tprint(2),tprint(3),tprint(4)
4Ø      format(1x,"T=",I3,4(1Øx,F7.Ø))
5Ø continue
6Ø continue
   close(unit=2,file='prn')
   return
   end
```