REGIONAL FLOOD FREQUENCY USING STATISTICAL SCALING

EDUARDO A. VARAS

Professor Hydraulic and Environmental Engineering Dept., Pontificia Universidad Católica de Chile, Casilla 306, Correo 22, Santiago, Chile
(Tel: +562-354-4218, Fax: +562-354-5876, e-mail: evaras@ing.puc.cl)

Regional flood frequency analysis has been extensively used for design purposes since it was proposed by Benson (1962). This approach increases the reliability of flood estimates, reduces uncertainty present in at site measurements, makes use of all information available in an homogeneous region and allows estimation of peak flows in points with no observed records. The use of a regional procedure requires the estimation of a non-dimensional regional frequency curve and the establishment of a relationship to calculate the mean annual flood or some other index flood.

This paper proposes the use of statistical scaling to obtain the moments of the random variables and use them to estimate parameters of probability distribution models to represent flood flows. This alternative approach has the advantage that no separate procedure is needed to obtain an estimate of the mean annual flood at each location and that if simple scaling is applicable, parameters can be obtained analyzing the relationship between first moments in the region.

Statistical scaling implies that time series for different scales can be represented by the same probability model and that the moments of the random variable for different scales (space or time) are proportional to the scale transformation function. This means that the random variable (flood flows) for different scales (Q_a , Q_A) are represented by the same probability model.. Peak flows can be transformed to a different scale by means of the scale transformation function (h(a,A)). A simple form of the transformation function is a power function of the ratio of corresponding basin areas. In this case, the expected values at different scales (moments of order r of the distribution) are related by:

$$E(Q_a^r) = \left(\frac{a}{A}\right)^{r\beta} E(Q_A^r)$$

and hence

$$\ln(E[Q_a^r]) = \ln(E[Q_A^r]) + r\beta \ln(a / A)$$

First, second and if necessary higher order moments are estimated using the logarithmic relationships. Moments are used to calculate parameters for the probability models that represent floods. Once the distribution model is selected and parameters estimated, probabilities for different flood magnitudes can be assigned.

Two conventional regional methods and the scaling method were used to estimate the flood frequency curve at Loncomilla River in Las Brisas. These estimates were also compared with the frequency curve obtained with historical site observations. Results show that there is a close agreement between the values for different return periods estimated by all procedures. This resemblance is also appreciated in the estimation of the probabilities computed for different floods as shown in Figure 1.

A value of β parameter of 0.629 was obtained by regression methods. The ratio of the β parameter for the first and second moments is approximately 2, so simple scaling was assumed. The correlation coefficient of both relationships is 0.8.

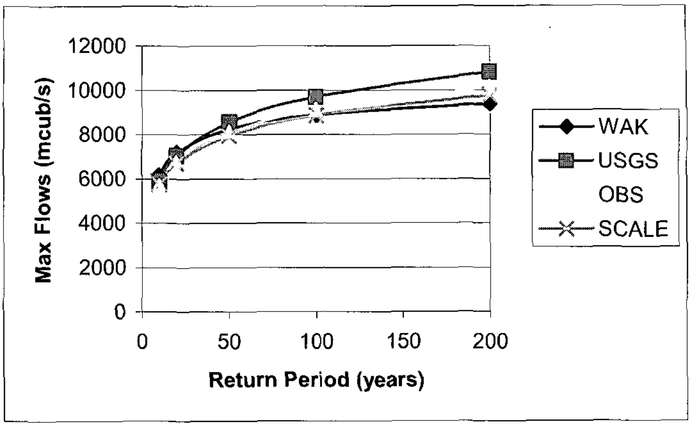

Fig. 1 Maximum daily flows at Loncomilla in las Brisas

Regional flood frequency methods using the Wakeby distribution, the USGS method and the scaling method give similar estimates of the flood frequency curve at the point of interest. This alternative method has the advantage that an accurate estimate of the β parameter can be obtained with the logarithmic relationship between the first central moments at each site.

The scaling method gives the closest estimates to the observed sample and requires only one parameter when simple scaling applies, which has also been the case in other test areas. An additional advantage of this method, is that if simple scaling holds, only the logarithmic relationship between the first order moments is necessary to obtain an estimate of β parameter. Another advantage of this method is that it can be used to identify hydrological homogeneous regions, since non-homogeneous regions tend to define different relationships to estimate moments.