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Flood Frequency Analysis Under Non-stationarity Conditions: the Case of Southern Brazilian Hydroelectric Power Plants

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Floods may be strongly affected by climate, land-use, land-cover and water infrastructure changes. However, it is common to model this process as stationary. This approach has been questioned, especially when it involves estimate of the frequency and magnitude of extreme events for designing and maintaining hydraulic structures, as those responsible for flood control and dams safety. Brazil is the third largest producer of hydroelectricity in the world and many of the country's dams are located in the Southern Region. So, it seems appropriate to investigate the presence of non-stationarity in the affluence in these plants.
In our study, we used historical flood data from the Brazilian National Grid Operator (ONS) to explore trends in annual maxima in river flow of the 38 main rivers flowing to Southern Brazilian reservoirs (records range from 43 to 84 years). In the analysis, we assumed a two-parameter log-normal distribution a linear regression model was applied in order to allow for the mean to vary with time. We computed recurrence reduction factors to characterize changes in the return period of an initially estimated 100 year-flood by a log-normal stationary model. To evaluate whether or not a particular site exhibits positive trend, we only considered data series with linear regression slope coefficients that exhibit significance levels ($p<0,05$). The significance level was calculated using the one-sided Student's test. The trend model residuals were analyzed using the Anderson-Darling normality test, the Durbin-Watson test for the independence and the Breusch-Pagan test for heteroscedasticity.
Our results showed that 22 of the 38 data series analyzed have a significant positive trend. The trends were mainly in three large basins: Iguazu, Uruguay and Paranapanema, which suffered changes in land use and flow regularization in the last years. The calculated return period for the series that presented positive trend varied from 50 to 77 years for a 100 year-flood estimated by stationary model when considering a planning horizon equal to ten years. We conclude that attention should be given for future projects developed in this area, including the incorporation of non-stationarity analysis, search for answers to such changes and incorporation of new data to increase the reliability of the estimates.