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Uncertainty analysis of a snowmelt runoff model using a possibility theory based method and the GLUE methodology

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The discharge estimates provided by watershed models are affected by uncertainties in hydrological data, model structure and model parameters. This study presents the analysis of predictive uncertainty due to parameter uncertainties of a snowmelt runoff model. Prediction uncertainty bounds are derived using the inference rules of possibility theory and also using the Generalized Likelihood Uncertainty Estimation (GLUE) methodology. Results of both methods are compared.

The model analysed is a conceptual watershed model operating at a monthly time step. The model divides the catchment into five elevation zones, where the fifth zone corresponds to the catchment glaciers. The catchment case study is Aconcagua River at Chacabuquito, located in the Andean region of Central Chile. This is a snowmelt dominated catchment with a surface of 2400[Km2], where approximately 5% corresponds to glaciers. Elevation ranges from 1030[m.a.s.l.] to 5930[m.a.s.l.]. Most precipitation occurs between May and August, while precipitation amounts during the rest of the year are relatively low. Monthly mean discharge is minimal in May-August, but it increments during the melting season September-March.

The mean squared error of the Box-Cox transformed discharge during the calibration period is used for the evaluation of the goodness of fit of the model realizations from a Monte Carlo sample. The model rejection criterion for the application of both the possibilistic method and GLUE consists in the removal of the model realizations whose mean squared error of the Box-Cox transformed discharge is greater than the variance of the Box-Cox transformed observations during the calibration period. At each time step, possibility distributions and GLUE type probability distributions of the discharge estimates are subsequently derived. Possibilistic uncertainty bounds during the verification period are obtained at possibility levels α=0.5, 0.75 and 0.9. Similarly, GLUE-type uncertainty bounds are derived at the probability levels p=85%, 90% and 95%.

Prediction uncertainty bounds obtained with both methods are relatively wide, especially during the snowmelt period, indicating that predictive uncertainty of the model when applied to the catchment case study is large. As expected, increasing the possibility level has a narrowing effect in the possibility bounds, at the cost of increasing the number of outliers from 2% at possibility level α=0.5 to about 11% at possibility level α=0.9. Decreasing the probability level of GLUE uncertainty bounds reduces their prediction width, but increments the fraction of observations not enclosed from 12% at probability level p=95% to 33% at probability level p=85%. Overall, it was found that the fraction of observations not enclosed by the possibility bounds at a given possibility level is generally lower than that corresponding to the GLUE uncertainty bounds of a similar width.

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