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Hybrid Model Approach To Water Monitoring Network Design

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HYBRID MODEL APPROACH TO WATER MONITORING NETWORK DESIGN

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Hybrid modeling approach including regionalization method, entropy technique, and Bayesian multiobjective optimization algorithm is proposed for optimum water monitoring network design. For hydrometric network design, all the components of the hybrid model are used as follows. Robust regionalization method is used to generate streamflow at all possible locations of new stations, and dual entropy-multiobjective optimization methods are used to optimize the number and locations of the new stations. For precipitation (rainfall or snowfall) network design, only the dual entropy-multiobjective optimization modules are used to optimize the number and locations of new stations based on an initial grid points which can be from remote sensing database (e.g. SNODAS) or interpolated ground observations. In addition to joint entropy and total correlation, other constraints such as cost, flow signatures, and watershed alteration indicators can be added to further optimize the number and locations of new stations. The hybrid model can also be applied to classified physiographic units to design optimal minimum network that meets the World Meteorological Organization minimum network standards.

HYBRID MODEL APPROACH

The model includes a regionalization module and a dual entropy-multiobjective optimization (DEMO) component. For streamflow network design, the outlet of each sub-basin can be selected as a potential location of a new streamflow gauge. Streamflow at each potential (ungauged) site is determined by coupling the drainage-area ratio and spatial proximity (inverse distance weighting) (DAR-IDW) methods. Following Samuel *et al.* (2013), the combined DAR-IDW method is used to estimate the flow at each ungauged site.

DEMO uses the epsilon-dominance hierarchical Bayesian optimization algorithm (ε-hBOA), which is a multi-objective evolutionary algorithm (Kollat *et al*. 2008), to evolve a set of network solutions. The benefit of ε-hBOA over other evolutionary algorithms is that it uses Bayesian network (probabilistic) models to express and preserve the interdependencies of the decision variables through the evolutionary process (Kollat *et al*. 2008). During the ε-hBOA computational procedure, each potential gauge site can be set as either on or off (1 or 0) by the evolutionary algorithm. Each solution seeks to find the set of N additional stations that optimally complement the set of M existing stations so that the final $M+N$ stations of the solution maximizes the information content of the solution. The ε-hBOA will search for Pareto-optimal solutions based on either the maximization of a set of objective functions selected for a particular network. The first two objective functions which are fundamental to the hybrid model are the joint entropy and total correlation. Combined, these objectives provide a measure of the information content of the network. Maximizing the joint entropy provides the first information based objective function. The second information content based objective function is the total correlation which is a measure of the information redundancy. Minimization of the total correlation results in a network with the least amount of shared information between stations. These two objectives provide much of the information used by ε-hBOA to search for an optimal network. In addition, hydrological parameters such as streamflow signatures and indicators of hydrologic alterations can be included in the hybrid model as additional objective functions. A detailed description of the DEMO method is provided in Samuel et al. 2013.

The proposed hybrid model was successfully applied in different watersheds for streamflow network design, precipitation network design, and snow monitoring network design. Application results will be presented and discussed. Some of the results are provided in Samuel et al. 2013.

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References

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