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Extending data worth methods to select multiple observations targeting specific hydrological predictions of interest

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Hydrological models are often developed to forecasting future behavior in response due to natural or human induced changes in stresses affecting hydrologic systems. Commonly, these models are conceptualized and calibrated based on existing data/information about the hydrological conditions. However, most hydrologic systems lack sufficient data to constrain models with adequate certainty to support robust decision making. Therefore, a key element of a hydrologic study is the selection of additional data to improve model performance. Given the nature of hydrologic investigations, it is not practical to select data sequentially, i.e. to choose the next observation, collect it, refine the model, and then repeat the process. Rather, for timing and financial reasons, measurement campaigns include multiple wells or sampling points. There is a growing body of literature aimed at defining the expected data worth based on existing models. However, these are almost all limited to identifying single additional observations. In this study, we present a methodology for simultaneously selecting multiple potential new observations based on their expected ability to reduce the uncertainty of the forecasts of interest. This methodology is based on linear estimates of the predictive uncertainty, and it can be used to determine the optimal combinations of measurements (location and number) established to reduce the uncertainty of multiple predictions. The outcome of the analysis is an estimate of the optimal sampling locations; the optimal number of samples; as well as a probability map showing the locations within the investigated area that are most likely to provide useful information about the forecasting of interest.