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Comparison of continuous time rainfall-runoff model, event based model and statistical methods to estimate floods at ungauged rural small catchments

Aynalem Tsegaw (1) and Knut Alfredsen (2)

(1) Norwegian University of Science and Technology, Trondheim, Norway (aynalem.t.tasachew@ntnu.no), (2) Norwegian University of Science and Technology, Trondheim, Norway (knut.alfredsen@ntnu.no)

Simple event based conceptual hydrological models and statistical methods are the widely and commonly used methods to estimate floods at small-ungauged rural catchments, and continuous time rainfall-runoff models are also becoming more common. The simple concept models consider some relevant hydrological processes, but they are criticized for the following reasons: for containing parameters which are difficult to estimate, for not considering the antecedent moisture condition of the ground and for being founded upon questionable assumptions. The continuous models have the advantage of incorporating the moisture and ground condition prior to the flood producing precipitation event, and they able to include the contribution of flow from the ground water to the peak flood. The lack of availability of high spatial and temporal resolution hydro-climatological and geographical input data for calibration and validation is the main challenge in these models.
In this study, we have compared three of the flood estimation methods used in Norway: the distance distribution dynamics (DDD) continuous model, the rational formula (simple event based model) and the NIFS formula (a national statistical formula developed to calculate peak flood flows in small catchments (< 50 km2) as a part of the Nature, Infrastructure, Flood, Landslide (NIFS) project). DDD is being used to estimate flood at the Norwegian Water Resources and Energy Directorate (NVE) with time steps of three and twenty-four hours. Since the response time of small catchments is short, we need to evaluate the model and regionalize the model parameters with a shorter time step before using in small catchments. Accordingly, we have regionalized and evaluated the model parameters with hourly temporal resolution using 41 small gauged catchments in Norway with three regionalization methods. The methods have been tested at seven independent catchments with cross-validation. The multiple regression method of regionalization has given the best performance of all the methods tested and even better than local calibration results for some of the test catchments. The three flood estimation methods have been applied to estimate design floods at both gauged and ungauged catchments. The DDD model can produce different magnitudes of flood for the same flood producing precipitation events for different antecedent moisture and ground conditions while the rational formula, and NIFS formula gave the same magnitudes. When the contribution from snowmelt is significant, the same magnitude of flood producing precipitation event gives a higher flood magnitude in May than in August at similar antecedent ground moisture condition. The use of continuous rainfall-runoff hydrological models also has the advantage and potential in studying flood risk management in small rural catchments under future land use and climate with a better understanding of the hydrology leading up to the flood event.