Uncertainty Assessment in Water Balance Modelling for Lake Victoria

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Abstract

The analysis of the water balance of Lake Victoria is constrained by limitations of data availability in terms of quantity and quality, both of which exhibit temporal and spatial variability around the basin. Lack of long term measurements on the lake surface complicates the estimation of lake rainfall and evaporation, the two largest variables. This thesis presents an approach to modelling the water balance of Lake Victoria that takes into account uncertainties in the most error-prone variables. A spatially detailed gridded rainfall dataset for the land part of the basin was derived using two interpolation methods. Studies were carried out of the temporal rainfall variability in the basin which showed that, during the twentieth century, annual rainfall trends were mainly positive, averaging an increase in basin rainfall of about 25%. Two satellite rainfall products were assessed on how well they reproduced the increased rainfall amounts on the lake surface compared to the land. Uncertainties in rainfall were based on accounting for errors in land rainfall interpolation and lake rainfall regression.

A two step approach was used to estimate catchment inflow, namely (1) rainfall-runoff modelling for gauged basins and, (2) regionalisation to estimate flow from ungauged basins. Uncertainties in catchment inflow were estimated using Monte Carlo simulation within a GLUE framework. Uncertainties in lake evaporation were estimated within a framework of sensitivity analysis. Water balance modelling studies involved propagating the uncertainties in lake rainfall, catchment inflow and lake evaporation through a lake water balance model to assess their effects on variations in lake levels and net basin supplies. Both monthly and annual predictions of net basin supply closely matched the observations on average with many of the observations falling within the prediction ranges. It was shown that uncertainties in the different water balance components tend to result in larger uncertainties in net basin supply. A seasonal analysis showed that October-December seasonal rainfall had a stronger contribution to the annual variability in net basin supply compared to the more abundant March-May rainfall.

The studies presented in this thesis provide a platform for carrying out assessments for utilisation of water resources in the Lake Victoria basin. Such studies could include lake regulation for optimum hydropower production, water resource utilisation studies and land-use or climate change studies. This thesis also recognises the importance of detailed measurements, especially for lake rainfall and evaporation, to resolve the water balance issues of Lake Victoria.

Keywords: catchment inflow, energy balance, ensemble regionalisation, GLUE, inverse distance weighting, rainfall, regionalisation, spatial interpolation, temporal variability, uncertainty assessment, universal kriging, WASMOD, water balance, Lake Victoria