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Modelling exploration of non-stationary hydrological system

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Traditional hydrological modelling assumes that the catchment does not change with time (i.e. stationary conditions) which means the model calibrated for the historical period is valid for the future period. However, in reality, due to change of climate and catchment conditions this stationarity assumption may not be valid in the future. It is a challenge to make the hydrological model adaptive to the future climate and catchment conditions that are not observable at the present time. In this study a lumped conceptual rainfall–runoff model called IHACRES was applied to a catchment in southwest England. Long observation data from 1961 to 2008 were used and seasonal calibration (in this study only summer period is further explored because it is more sensitive to climate and land cover change than the other three seasons) has been done since there are significant seasonal rainfall patterns. We expect that the model performance can be improved by calibrating the model based on individual seasons. The data is split into calibration and validation periods with the intention of using the validation period to represent the future unobserved situations. The success of the non-stationary model will depend not only on good performance during the calibration period but also the validation period. Initially, the calibration is based on changing the model parameters with time. Methodology is proposed to adapt the parameters using the step forward and backward selection schemes. However, in the validation both the forward and backward multiple parameter changing models failed. One problem is that the regression with time is not reliable since the trend may not be in a monotonic linear relationship with time. The second issue is that changing multiple parameters makes the selection process very complex which is time consuming and not effective in the validation period. As a result, two new concepts are explored. First, only one parameter is selected for adjustment while the other parameters are set as constant. Secondly, regression is made against climate condition instead of against time. It has been found that such a new approach is very effective and this non-stationary model worked very well both in the calibration and validation period. Although the catchment is specific in southwest England and the data are for only the summer period, the methodology proposed in this study is general and applicable to other catchments. We hope this study will stimulate the hydrological community to explore a variety of sites so that valuable experiences and knowledge could be gained to improve our understanding of such a complex modelling issue in climate change impact assessment.