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Significance of the Nash-Sutcliffe efficiency measure for linear rise and exponential recession in event based flood modelling

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The evaluation of model performance is of primary importance, not only in model development and calibration, but also to compare modelling results on various catchments and to communicate the results to other modellers. For hydrologists, the Nash-Sutcliffe efficiency (NSE) measure [Nash and Sutcliffe, 1970] is the most commonly used criterion. The NSE is a convenient measure of model performance, but many studies had pointed out its limitations when comparing the results of different case studies. In addition, some authors have criticized this criterion as not being very informative on the simulated hydrograph's shape, yet few studies were undertaken to analyze the meaning of NSE, especially for event based applications, and to link its value to those of other criteria such as the error on volume and peakflows. In this work, we put forward a methodology to analyze the mathematical and hydrological value and significance of the NSE criterion on both the rising and falling limbs of the hydrograph as this differentiation is very important in flood routing application. The hydrograph rise is approximated by a line, and the recession by an exponential curve. The particular case of linear hydrograph rise and exponential hydrograph recession are extensively studied because an analytical expression of the NSE can be expressed. First, the main characteristics of storm hydrographs are analyzed. Then, the significance of the NSE are analysed for two particular cases : i) the hydrograph rise under the assumption of linear increase of discharge; ii) hydrograph recession under the assumption of an exponential decrease of discharge. Results show that for both particular cases, an analytical relation can be established between the NSE, the error on volume and the relative error on discharge. Finally a technique is proposed to guide

the modeller in multi-objective calibration applications. The technique is applied for multi-event flood routing modelling applications on the Loire River using three criteria (NSE, volume, relative error on discharge). The results indicate that this technique may be used to calibrate the model for only one criterion and to deduce the values of the remaining criteria analytically.