Seasonality of hydrological model spin-up time: a case study using the Xinanjiang model (doi:10.5194/hess-2016-316)

Author response for reviewer comments #1

1) The choice of a modelling application by the authors does not seem to be relevant for a spin-up study. As it is shown in the results, spin-up time of a conceptual lumped hydrologic model is quite short in the study catchments. In fact, the impact of initial condition is mostly disappeared in less than a year or two. In the conceptual hydrologic modelling literature, we often see that the first 2 or 3 years of simulation is considered as the warm-up period and removed from the rest of the analysis including model calibration. Therefore, it is not clear what are the implications of estimating spin-up time in conceptual hydrologic models considering their short spin-up times? Can we just remove the first two years of simulation as it is commonly performed? I agree with the authors that initialization is an important issue in hydrologic modelling. However, proper initialization of hydrologic models becomes more relevant in integrated hydrologic models where sub-surface and land surface processes are coupled and computational time is an important issue.

Author response: The importance of estimating model spin-up time is discusses in Rahman and Lu (2015).

We agree that conceptual lumped hydrological model spin-up time is quite short, and thus excluding initial model outcomes (warm-up period) is an easy solution to avoid errors associated with model initialization. Of course, we can simply remove first two years of simulations while performing analysis.
However, in some cases exclusion of one year model out outputs could be a very costly task in developing countries where hydro-climatic data is very scarce (say only 2-3 years of available data records). Over-estimating the spin-up period would lead to a loss of important information. Likewise, an underestimation would affect the conclusion by incorporating erroneous initial model outputs. Moreover, guessing spin-up time (if any) for a shorter period, particularly for seasonal or monthly simulation would be very problematic (Rahman and Lu, 2015). Arguing these limitations, Rahman and Lu (2015) discusses the variations of model spin-up time with basin hydro-climatic characteristics and suggest an easy way to estimate maximum spin-up time under extreme hydro-climatic and data scarce conditions with improved accuracies.

The comparative advantages of this manuscript over Rahman and Lu (2015) have been discussed in the manuscript. Please see Page-3, Line 29-34.

2) Another issue with the approach in the paper is that it seems model calibrations are performed at the same time to explore the impact of initial condition. Therefore, one would expect that the impact of initial condition is reduced through parameter adjustment during calibration. It will be very useful if authors can present possible differences in model parameters and performance between the various initializations as the model reaches equilibrium.

Author response: The model calibration and exploration of model spin-up time were performed separately (please see page-5, line-11-14). The Xinanjiang model was calibrated with saturated initial condition and thereafter the daily streamflow was validated against those of the observed by taking spin-up time long enough (10 year) to avoid the effects of the initial condition. Thereafter, these calibrated parameter values were exercised for the subsequent simulations that explores the impact of initial condition.

3) Why authors only used snow free catchments in their modelling study. The conceptual model used here runs quite fast and it is not clear why not all the MOPEX data is used in this study. At least this way, authors could expand their analysis and provide useful and informative discussion that will be useful for readers.

Author response: The studied river basins were selected intentionally mainly for two reasons.

Firstly, to maintain consistency with Rahman and Lu (2015) and Rahman et al. (2015) as they discussed model-spin-up time and soil moisture memory for the same river basins. As we mentioned earlier that Rahman and Lu (2015) discussed model spin-up time based on a different methodologies (single year recursive simulation) that of ours (multiyear climatologies). We prefer to analyze same river basins for comparing model spin-up outcomes derived from two different methodologies. On the other hand, Rahman et al. (2015) analyzed soil moisture memory (SMM) for the same river basins. Therefore, it enables to relate the model spin-up time and soil moisture memory. Since, soil moisture autocorrelation equation (based on what SMM was estimated) does not consider snow, Rahman et al. (2015) choose snow free MOPEX basins for analysis and ultimately led the selection of studied basin for the present study.

Secondly, experience suggests that the XAJ model does not produce better results for all the MOPEX basins, particularly for the drier basins (Kyi, 2014).

4) As authors have stated in their Introduction, Rahman and Lu (2015) have already estimated the maximum spin-up period of the Xinanjiang model using basin aridity index. Similarly seasonality of soil moisture memory (SMM) is already discussed in Rahman et al. (2015). Therefore, the novelty of this manuscript is not clear.

Author response: This study holds at least three major comparative advantages over the existing spin-up literatures including Rahman and Lu, 2015. Firstly, use of multi-year forcing allows to introduce inter-annual variability and overcome the limitations contains in single year recursive simulation in the sense of representativeness to the actual phenomenon. Secondly, it detects the model equilibrium state based on Mahalanobis Distance that is widely acceptable in the presence of co-linearity of datasets. Thirdly, it provides useful insights about the seasonality of model spin-up time that is missing in the available spin-up studies. The novelty of this manuscript has been discussed elaborately in Page-2, Line 22-41 and Page-3, Line-1-15.

SMM and model spin-up time is similar but not necessarily the same. Rahman et al. (2015) shows the variability of SMM based on basin hydro-climatic characteristics. On the other hand, this manuscript discusses the variations of model spin-up time based on the simulation starting time (and of course due to variations of hydro-climatic conditions). Understanding seasonality of both the phenomenon certainly improves the understanding of the hydrological research communities.

5) No information is provided about the seasonal characteristics of precipitation in the study basins. I suspect that seasonality of spin-up time is similar to the seasonality of precipitation patterns. Can authors discuss this?

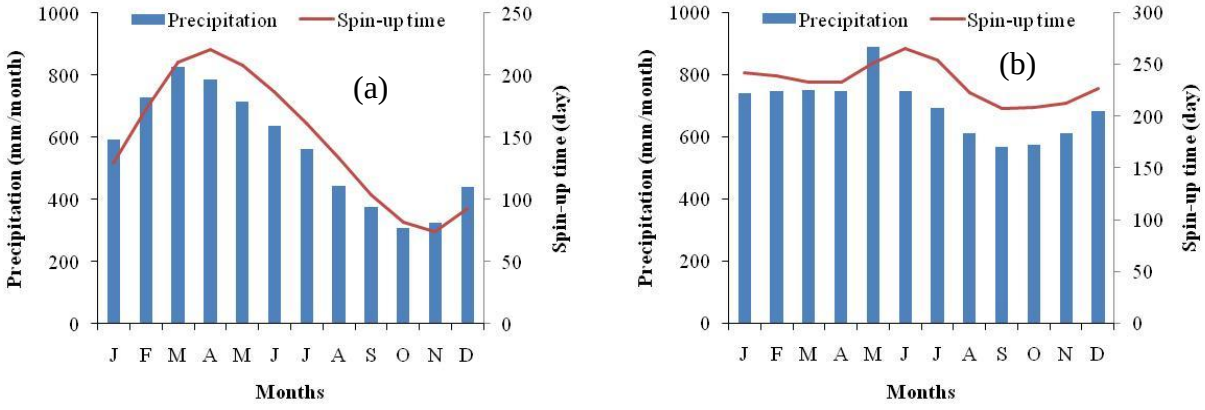

Fig. 1: Seasonality of precipitation and model spin-up time: (a) wet basins and (b) dry basins.

Author response: Thank you very much. You are right. Figure 1 suggests that, the seasonality of spin-up time is similar to the seasonality of precipitation. Monthly spin-up time shows strong correlation (r=0.87) with monthly total precipitation. The spin-up time was explored by declaring two extreme initial conditions (0% and 100% soil moisture). It is intuitive that the higher the distance between the mean condition and the initial condition, the longer the time requires reaching the equilibrium. The distance between the mean condition and any of the initial condition for the months with higher precipitation is wider as compared than that of months with lesser precipitation. Therefore, the higher the monthly precipitation, the larger the spin-up time is.

This discussion will be added into the manuscript.

6) It will be very important that authors discuss their results and explain the factors impacting observed behaviour here. More importantly, authors should discuss the implications of their study and its broader impact for hydrologic modelling community.

Author response: The study provides important information to the modeling community, particularly for those who works under data scarce situation. It reveals the seasonality of spin-up time and explains the control of spin-up behavior. Additionally, it suggests an easy way to estimate the spin-up time using only the precipitation and potential evapotranspiration information. Estimating spin-up time could improve modeling efficiency under data scarce situation.

7) Regarding the calibration, no information is provided about the calibration approach and the length of calibration and evaluation periods.

Author response: Please see author response of question no. 2.

8) Why spin-up time is longer if the start time of a simulation is in spring? Can authors provide further details.

Author response: In wet basins the spin-up time is longer while the simulation starts in spring. Figure 1 agrees that the spring months' precipitation is higher as compared that of other months. Please also see explanation in question no. 5.

9) In Page 2 –Line 4: authors state "These techniques of reducing spin-up errors hold certain limitations". Can authors discuss these limitations? There are multiple papers that examined the use of various spin-up criteria in both land surface and integrated hydrologic models and it is not clear what authors are referring to it here.

Author response: This is refers to the limitations contained in guessing spin-up time. The limitations are explained in author response to the question no. 1.

The explanation will be added into the manuscript.

References:

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