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LM4-SHARC v1.0: resolving the catchment-scale soil–hillslope aquifer–river continuum for the GFDL Earth system modeling framework

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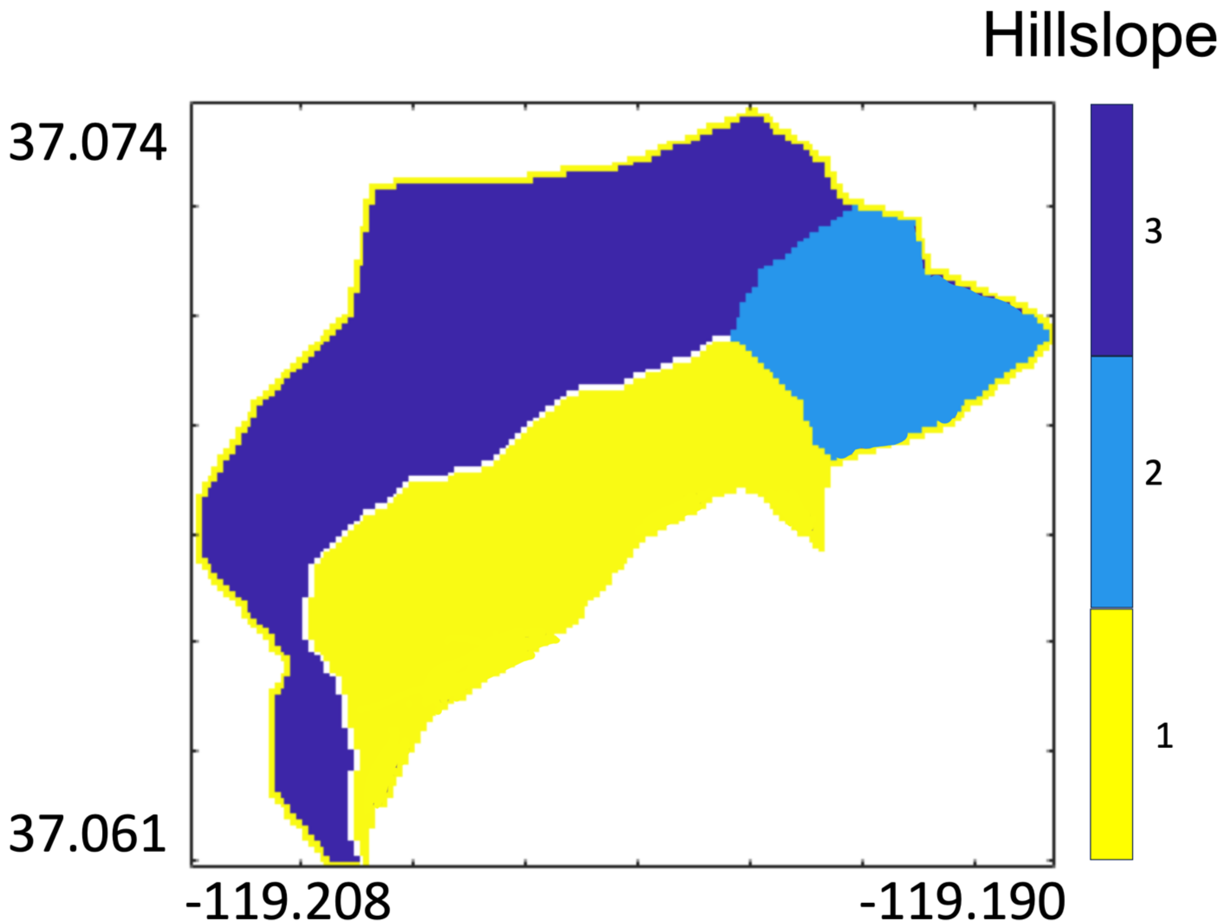

Figure S1 Schematic showing how hillslopes were determined and described in the study catchment. Since it is a headwater catchment, the catchment were divided into three hillslopes and the height bands (i.e., HB1-6, intra-hillslope heterogeneity using surface elevation data) were established in each hillslope.

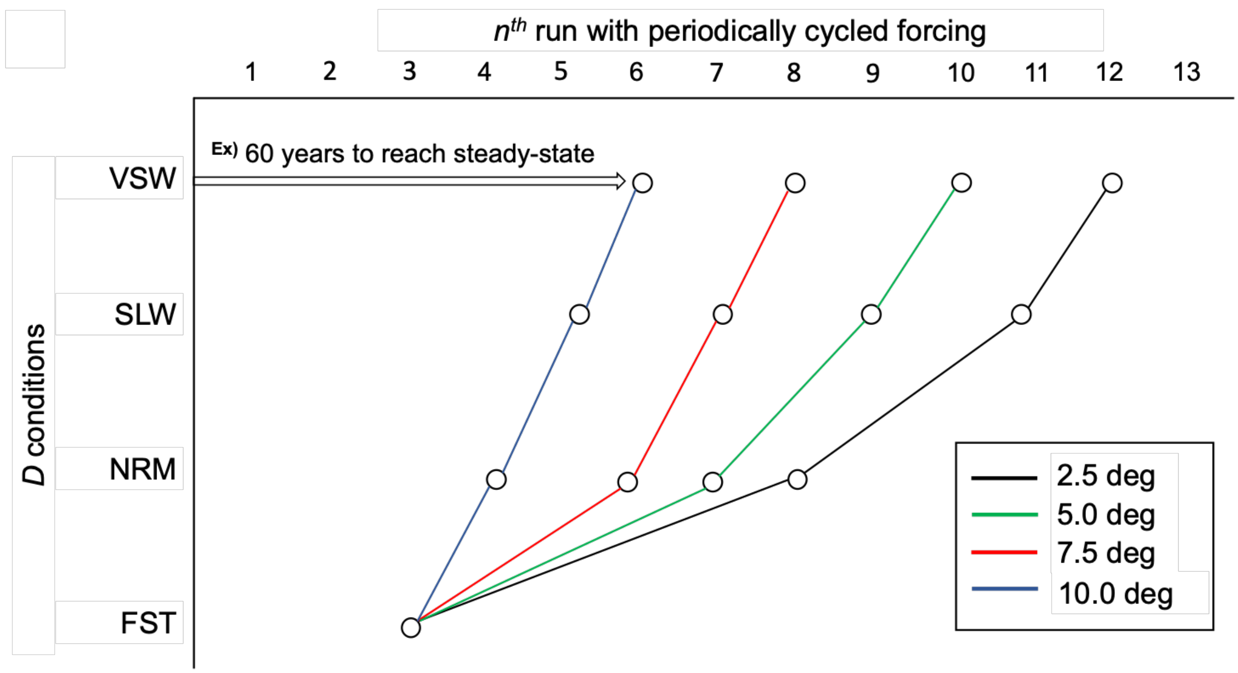

Figure S2 Four distinct groundwater diffusivity *D* conditions are considered. In addition to the three *D* conditions considered in Section 4.1, an additional consideration of a very slow flow *D* case (i.e., VSW, K_s=1.0 · 10^{-3} mm s^{-1}, *f* =0.2) was made to investigate the expected spin-up time when the lateral groundwater discharge flux is very slow. We found that the spin-up took less time (i.e., a smaller number of 10-year repeated cycles) as *D* increased, meaning that the LM4-SHARC reached a steady state more quickly with the faster groundwater discharge. It turned out that the faster flux estimates could contribute more efficiently to the convergence of other groundwater discharge-related variables (in the adjacent model domains), leading to a less spin-up time. Likewise, from the comparison at the identical *D* condition, the slope θ can change the spin-up time by affecting the flux velocity. This is because the q_l increases with increasing bedrock slope due to higher quantitative growth rate of gravitationally-driven q_l component compared to its diffusion-driven component. As a result, in our estimates the spin-up times at the VSW condition range from 60 – 120 years, at the SLW condition 50 – 110 years, and at the NRM condition 40 – 80 years. We found the spin-up time in FST conditions to be 30 years, and to be independent of θ.

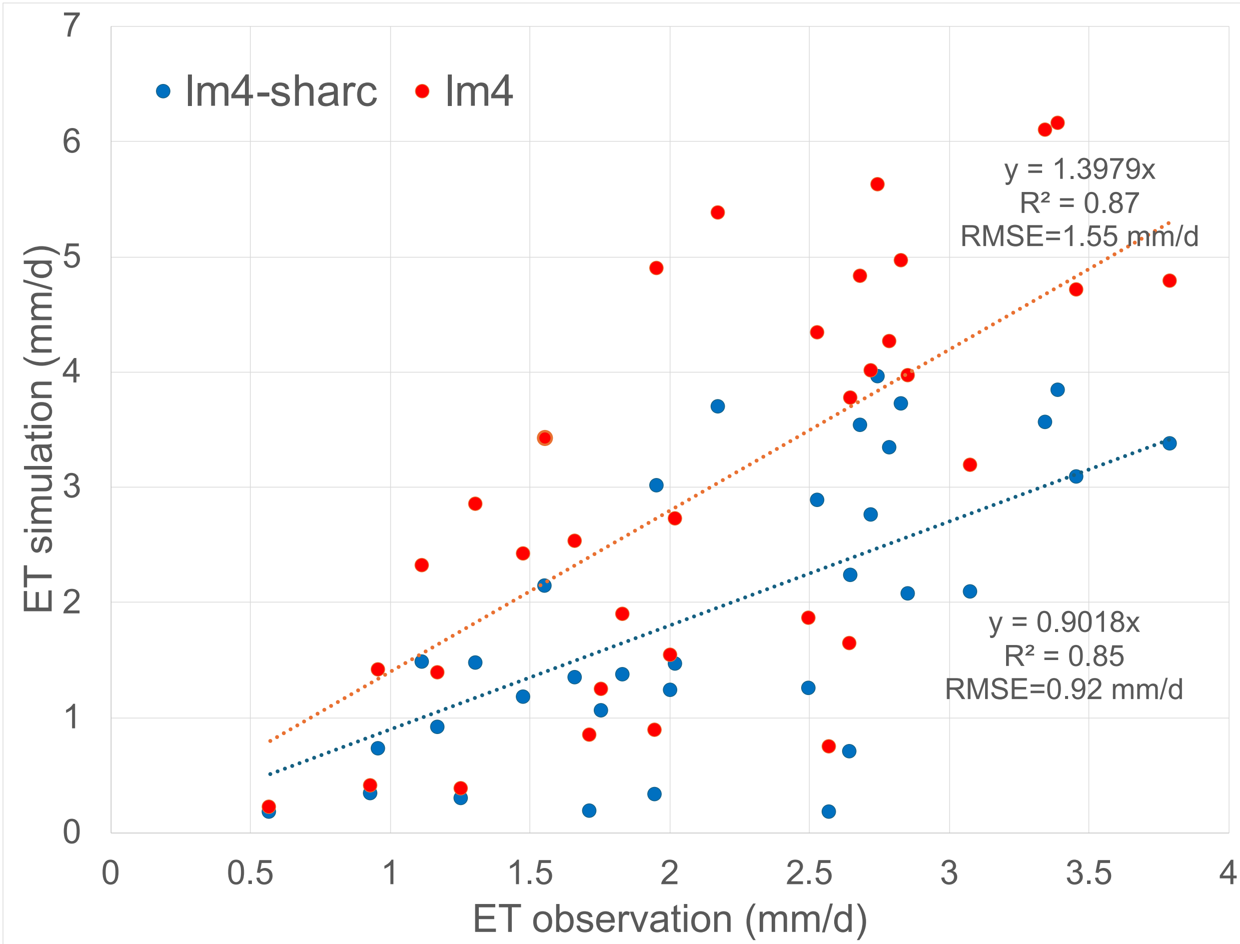

Figure S3 Evapotranspiration comparison between observations and simulations derived from the respective LM4-SHARC and LM4-HydroBlocks (in the above figure, lm4 denotes LM4-HydroBlocks). For ET observational data, the vapor flux observations measured from flux tower located within the Providence Creek headwater catchment was used. Since observations that only measure 'transpiration' is not available and the vapor flux observations measure ET (i.e., evaporation + transpiration), we compared simulated ET against observed ET when transpiration is above zero. Linear regressions performed on each data pairs with a fixed intercept of zero show that the slope changed from 1.3979 to 0.9018, and RMSE improvement from 1.55 mm/day to 0.92 mm/day implying significant improvements in predicting ET magnitudes. The temporal agreement between the simulated and observed ET, indicated by R^2, was slightly reduced in LM4-SHARC, but still kept the R^2 above 0.85. We also note that about 33.5 percent of the observations during the total observation period was missing and the loss of approximately one-third of the data reduces the reliability of this comparison.