Justification for application of GRACE data (0.5^0 resolution) to smaller catchments

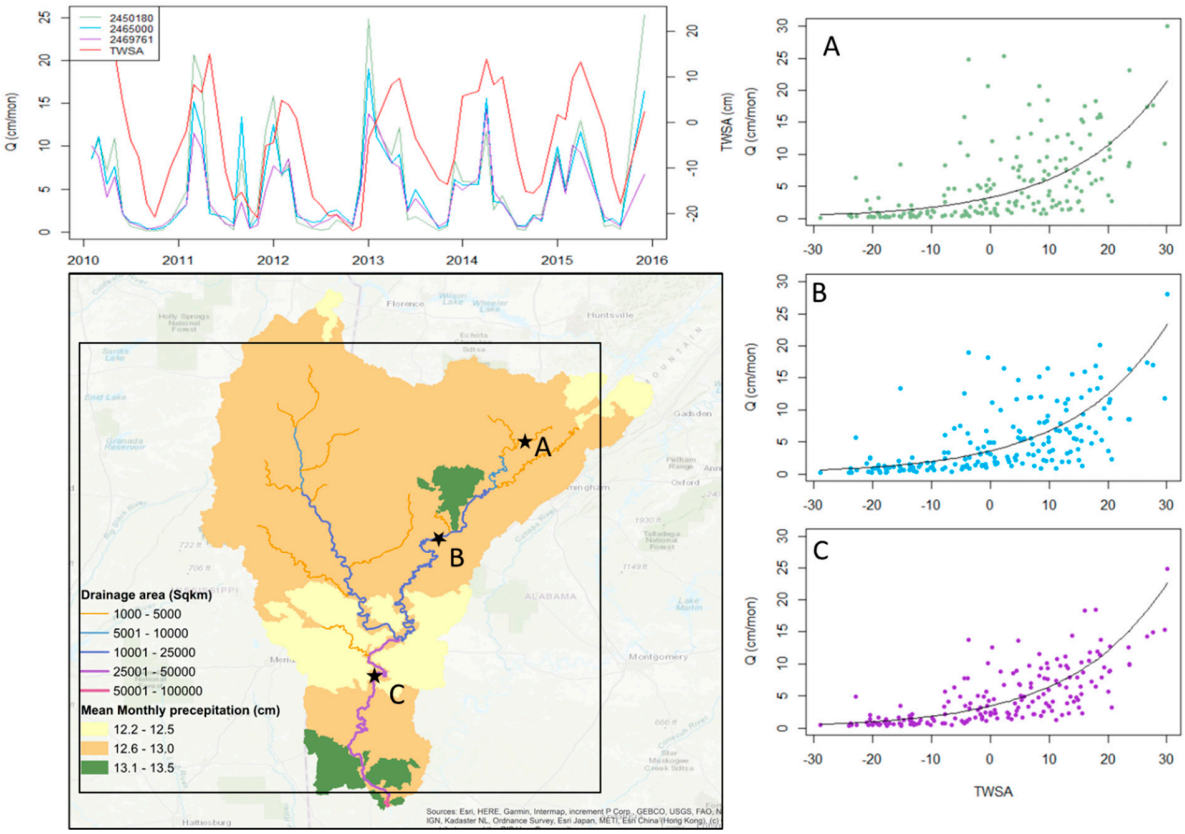

Figure S1 A watershed in lower Mississippi inside one single pixel and 3 gauges with different Drainage area. The hydrograph and Q vs *TWSA* graph are plotted.

Figure S1shows an example of a watershed mostly contained within one native resolution 3.0 by 3.0 degree GRACE pixel (i.e., same *TWSA* value throughout the watershed). The river network within the GRACE pixel is also shown with drainage areas varying from 1,000 to roughly 50,000 km2 when it crosses the pixel boundary. For clarity, only rivers draining more than 1,000 km2 are highlighted. The mean monthly precipitation of the catchment is represented using the color scale and ranges from 12 to 14 cm. In this study, the *TWSA* values for each river reach within the watershed are averaged over all the upstream drainage areas. Although the magnitude of the streamflow increases along the river network (as shown in the Figure S1), the increase is largely driven by accumulation of land area due to the relatively uniform pattern in precipitation. Thus, the network approach for integrating *TWSA* values within catchments draining land areas much finer than the native GRACE resolution, provides useful insights in regions where monthly precipitation is relatively uniform. In this example, we show the native resolution of GRACE (3 x 3 degrees). The product resolution (0.5 x 0.5 degrees) can be further downscaled based on scale factors derived from land surface models results suggesting the required spatial scale of relatively uniform monthly precipitation can be even finer. In locations where this concept does not apply (i.e., highly variable spatial precipitation), the performance of the optimized models is potentially impacted. However, where this concept applies, the performance of the optimized models can be good even when the drainage area is less than 1,000 km2.

Maps of *KGE*

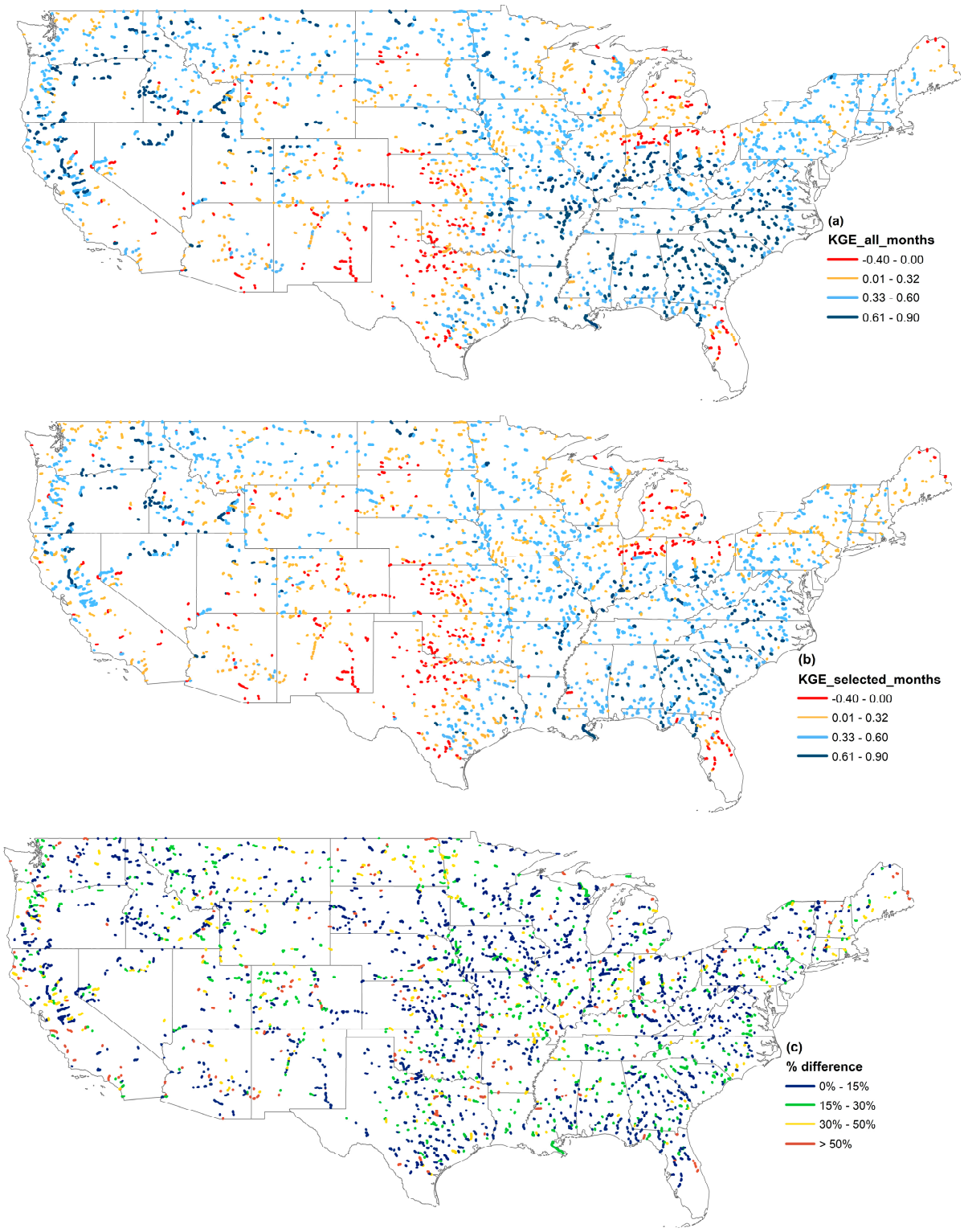

Figure S2 Maps of the following A. The *KGE* of the optimized model on all the 12 months. B. *KGE* of the optimised models on the subsetted (optimized) months. The subsetted months are the months during

which the exponential relation exists between *TWSA* and discharge. C. The difference between these two types of *KGE*.