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Parameter compatibility under scale-dependent condition of distributed rainfall-runoff modeling

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Distributed models are becoming commonplace in a variety of hydrologic applications. Moreover, it is not surprising that GIS have become an integral part of hydrologic researches considering spatial heterogeneity of model parameters and input data like precipitation, controlling hydrologic process. A number of distributed models have been developed and used worldwide for hydrological studies, from simple streamflow estimation to impact of climatic change due to global warming. However, despite its effectiveness, it is still questionable to choose the suitable size of spatial resolution. Drainage network may be derived from DEM so that its resolution has a direct influence on the total drainage length (e.g., slope edge, river edge) and slope. The variations of drainage length and slope due to upscaled or downscaled DEMs effect on the catchment response such as runoff simulation, sedimentation yield and so on.

Actually, physics-based models do not need calibration because of perfect knowledge of the parameter values distributed throughout the watershed and of the spatiotemporally variable rainfall input. But, it is impossible to avoid calibration to searching for the optimal parameter combination since no matter how sophisticated hydrologic models may be they are just simplifications of real natural systems. Hydrologists have argued that there are too many degrees of freedom in distributed modeling because considerable parameters and input observations are required and then numerous plausible parameter sets can be presented in response surface in terms of objective function. Another difficulty of the calibration procedure in distributed modeling is the computational burden when we calibrate the model based on very fine resolution DEM. Indeed, calibration time of the model based on 50m spatial resolution by using global automatic optimization method is approximately larger 100 times than the model based on 500m DEM.

In this study, we calibrated five different models based on different spatial resolutions, from 50m to 1km, using Shuffled Complex Evolution (SCE) algorithm with SLS as an objective function and then tested the parameter compatibility through cross-applications. The results show that all of model performances with optimal parameter sets were good (Nash-Sutcliffe coefficient > 0.95) and the optimal parameter sets based on coarser DEMs were well applicable for hydrograph simulations for finer resolution based models while applications to the contrary showed very poor model performances. One of the interesting findings is that the model with the finest resolution (50m) did not guarantee the best parameter compatibility. Instead, 250m based model gave the most stable model performances regardless of parameter sets obtained from different DEMs.

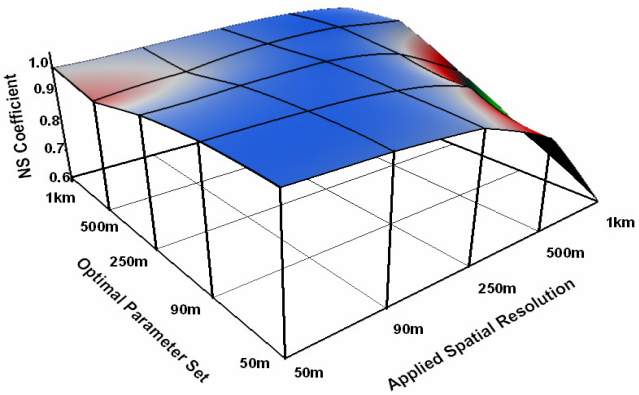

Fig.1 Summary of test for parameter compatibility