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Use of the Sacramento Soil Moisture Accounting Model in Areas with Insufficient Forcing Data

V. Kuzmin

Russian State Hydrometeorological University, Saint Petersburg, Russia (e-mail Vadim.Kuzmin@yahoo.com)

The Sacramento Soil Moisture Accounting model (SAC-SMA) is known as a very reliable and effective hydrological model. It is widely used by the U.S. National Weather Service (NWS) and many organizations in other countries for operational forecasting of flash floods. As a purely conceptual model, the SAC-SMA requires a periodic re-calibration. However, this procedure is not trivial in watersheds with little or no historical data, in areas with changing watershed properties, in a changing climate environment, in regions with low quality and low spatial resolution forcing data etc. In such cases, so-called physically based models with measurable parameters also may not be an alternative, because they usually require high quality forcing data and, hence, are quite expensive. Therefore, this type of models can not be implemented in countries with scarce surface observation data.

To resolve this problem, we offer using a very fast and efficient automatic calibration algorithm, a Stepwise Line Search (SLS), which has been implementing in NWS since 2005, and also its modifications that were developed especially for automated operational forecasting of flash floods in regions where high resolution and high quality forcing data are not available. The SLS-family includes several simple yet efficient calibration algorithms:

1) SLS-F, which supposes simultaneous natural smoothing of the response surface by quasi-local estimation of F-indices, what allows finding the most stable and reliable parameters that can be different from “global” optima in usual sense. (Thus, this method slightly transforms the original objective function);

2) SLS-2L (Two-Loop SLS), which is suitable for basins where hydraulic properties of soil are unknown;

3) SLS-2LF, which represents a conjunction of the SLS-F and SLS-2L algorithms and allows obtaining the SAC-SMA parameters that can be transferred to ungauged catchments;

4) SLS-E, which also supposes stochastic filtering of the model input through generation of ensembles of its noises. (In addition, this algorithm can be used for the forecasts post-processing).

Our experiments have demonstrated high efficiency of those approaches and possibility of their practical implementation in the SAC-SMA-based automated systems of operational flash flood forecasting (existing or under development) in Russia and other countries with insufficient surface observation data and a great number of streams, in areas with changing watershed properties, in a changing climate environment, in ungauged catchments etc.