Assimilation of soil moisture data for improving streamflow prediction: Is there a role for the hydrological model structure?

Nayak A K[1], Biswal B[3], and K.P. Sudheer[1,2]

1- Department of Civil Engineering, Indian Institute of Technology Madras, Chennai, India
2 - Department of Agricultural & Biological Engineering, Purdue University , West Lafayette, Indiana, USA
3 - Department of Civil Engineering, Indian Institute of Technology Bombay, Mumbai, India

EGU General Assembly 2020

Abstract ID: D267| EGU 2020-19109

Introduction

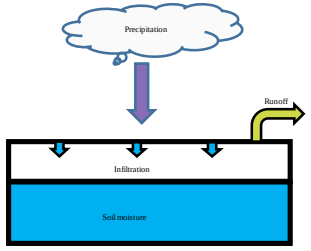

Figure. 1 Importance of Soil moisture in rainfall partitioning

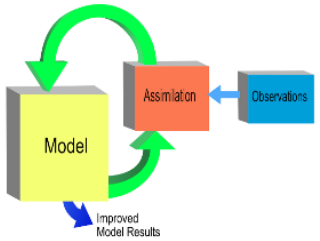

Figure. 2 A general Soil moisture data assimilation (SMDA) framework

- An accurate soil moisture (sm) estimation in hydrological models help in estimating runoff more accurately.

Research question

Is there a role of hydrological model structure in assimilation of sm for streamflow prediction?

Objective

To study the impact of variability in model structure on soil moisture assimilation in the context of streamflow prediction.

Data and study Basins

- The daily rainfall, PET, and discharge data from 1948 to 2000 obtained from the MOPEX data base along with daily root-zone sm from the GLDAS Version 2.
- For this study, 10 MOPEX basins were selected based on the criteria that the snowmelt contribution of the basin was less than 25% of the total flow.

Methodology

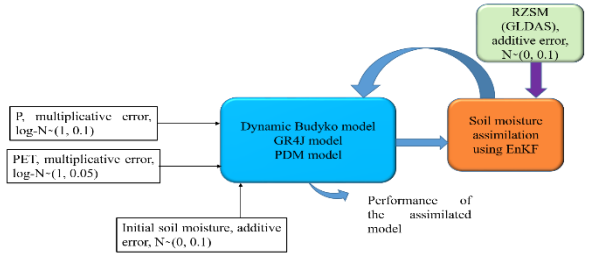

Figure. 3 Methodology flow chart

- Note that 100 ensembles are generated for the input and observation.
- Since the Instantaneous dryness-index (φ) is the state variable of the Dynamic Budyko (DB) model, relations between φ and soil moisture are developed for 10 basins.
- The bias correction is done to GLDAS soil moisture using mean-variance matching method

Results

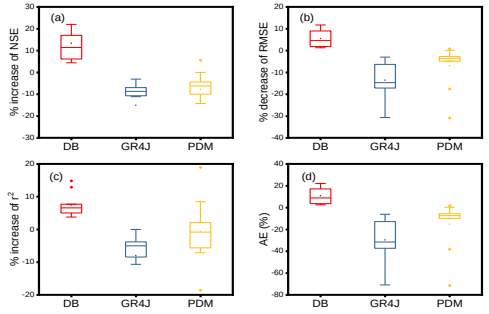

Figure. 4 Assimilated model performances in terms of (a) percentage increase of NSE, (b) percentage decrease of RMSE, and (c) percentage increase of r^2, along with (d) Assimilation efficiency (AE) of all the models for 10 basins. The simulation period used for the SMDA is from 1976 to 1978.

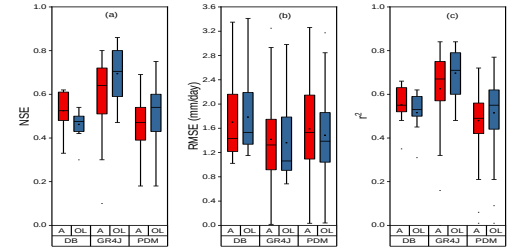

Figure. 5. Box plots showing performances in terms of (a) NSE, (b) RMSE, and (c) r^2 of the DB, GR4J, and PDM model for the assimilated (A) and the open-loop (OL) simulations for 10 basins. The simulation period used for SMDA is from 1976 to 1978.

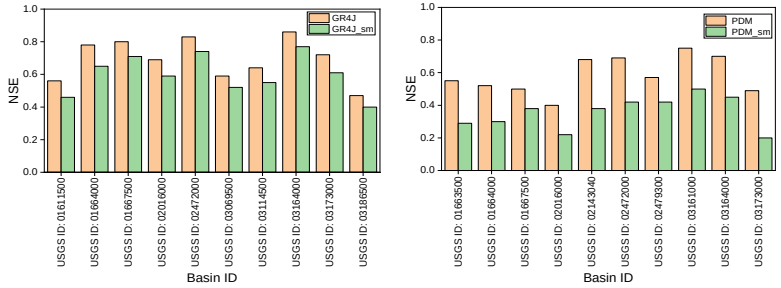

Figure. 6 The bar chart of the model performance in terms of NSE of the original GR4J and PDM model and the GR4J and PDM model in which the GLDAS soil moisture is replaced (GR4J_sm, PDM_sm). The simulation period is considered from 1976 to 1978. The model simulation performed deterministically to know what happened to the model performance after replacing GLDAS soil moisture over model estimated soil moisture.

Conclusions

- It was found that the improvement in the model performance due to SMDA is best for the DB model among all the three models.
- The model structure of the GR4J and PDM model represents sm better than that of the DB model.
- The GLDAS soil moisture was found to be only beneficial for the DB model not for the GR4J and PDM model.

Contact: arun03.iitkgp@gmail.com