Impact of Initial Soil Moisture on the Accuracy of WRF-Hydro Runoff Simulation

Chen Zhao (**zhao.2267@osu.edu**), Steven M. Quiring (quiring.10@osu.edu)

THE OHIO STATE UNIVERSITY

GEOGRAPHY

Motivation

Hydrological models that simulate runoff generation processes are strongly influenced by the amount and spatial distribution of antecedent soil moisture (Loew and Mauser 2008). Therefore, accurate assessment of the spatial and temporal dynamics of initial soil moisture is very important for the predictive capability of runoff models.

This study aims to investigate the impact of spatial variability of antecedent soil moisture on runoff at grid scale using a coupled system model--WRF-Hydro.

WRF-Hydro Coupling System

- ❑ WRF-Hydro is a coupled system, it couples the National Center for Atmospheric Research (NCAR) Weather Research and Forecasting model (WRF) model with Distributed Hydrologic Modeling System (NDHMS).
- ❑ WRF-Hydro could be run in a fully coupled mode with WRF or uncoupled (offline) mode. The fully coupled mode means that WRF-Hydro serves as a hydrological extension of WRF. Uncoupled mode use other forcing data to drive the model.

WRF-Hydro Configuration

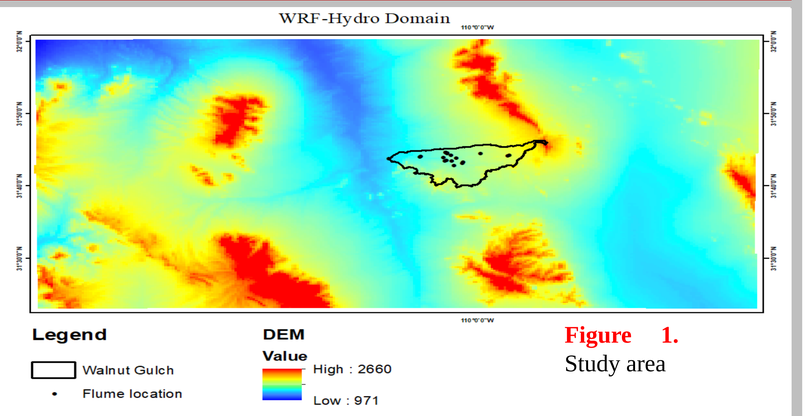


Figure 1. Study area

Domain resolution	**1 km**
Routing model resolution	**250 m**
Spin up time	**5/1/2015 to 5/10/2016**
Test Simulation time	**5/11/2016 to 9/27/2016**

Data

- Meteorological forcing

NLDAS L4 hourly 0.125*0.125 degree, regrid to 1 km

- DEM

USGS HydroSHEDS void-filled DEM, 15sec resolution, resampled to 1km

- Flume data

USDA ARS Southwest Watershed Research Center (Stone., 2008)

- Land use, soil and other terrain data

WPS V4 Geographical Static Data, regrid to 1km

Simulated Runoff with 4 Scenarios of Initial Soil Moisture

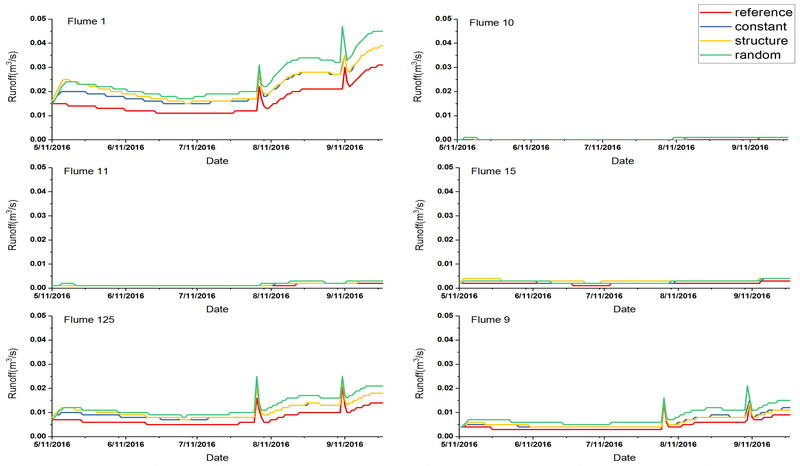


Figure 2. Hydrographs with 4 initial soil moisture conditions at 6 flume points

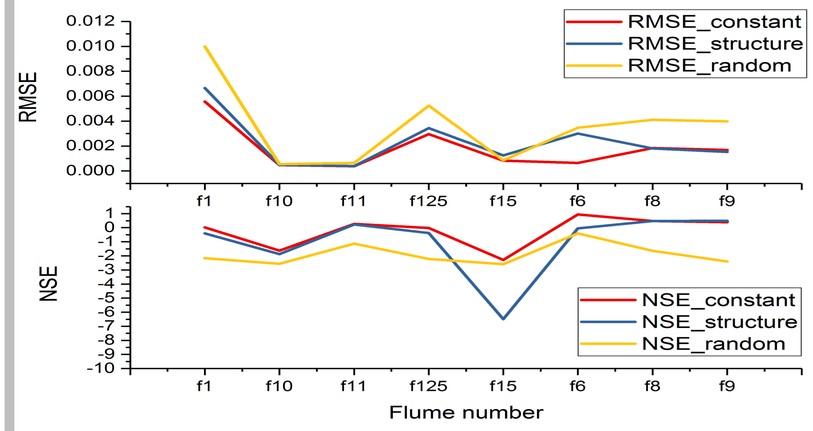


Figure 3. RMSE and NSE (Nash Sutcliffe Efficiency) between simulated runoff with reference soil moisture and simulated runoff with constant, structure and random soil moisture at each flume point

Soil Moisture Variation During Model Simulation

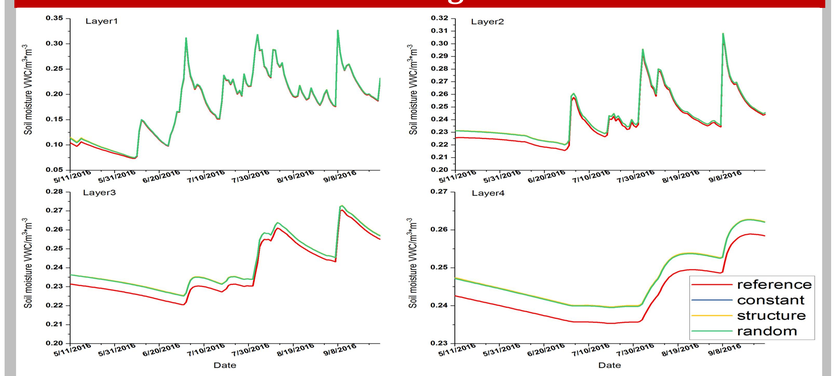
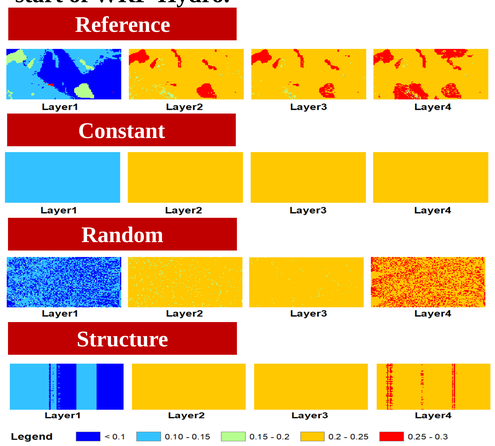


Figure 4. Daily area-average soil moisture from 5/11/2016 to 9/27/2016 at 4 layers

Soil Moisture Initial Conditions

Four scenarios of initial soil moisture conditions are tested using 'warm' start of WRF-Hydro.



Layer1 depth (m)	0.1
Layer2 depth (m)	0.3
Layer3 depth (m)	0.6
Layer4 depth (m)	1

Figure 5. Comparison of the 4 initial conditions of soil moisture VWC (%) for warm start simulation. Reference soil moisture is the model simulated result, constant is the mean for each layer, structured is the sorted values of reference based on Topographic Wetness Index, and random is the average of 1000 random permutation of reference soil moisture values.

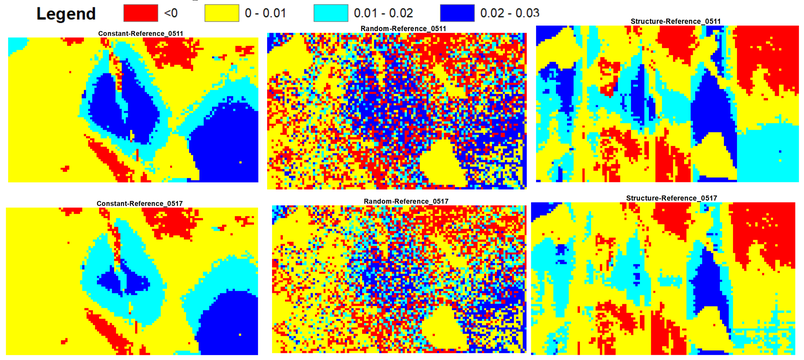


Figure 6. Differences between reference and constant, random, structure scenarios after one day and one week

Conclusions

- The runoff simulated by WRF-Hydro is strongly influenced by the spatial variability of initial soil moisture.
- In this study, based on the hydrograph, the deterministic spatial structure (constant) of initial soil moisture best describes the spatial structure of the soil moisture.

Next Steps

- ❑ Identify the impact of rainfall-runoff infiltration parameters (REFKDT, OVROUGHRT, RETDEPRT, and MANN) on the runoff simulation for this domain.
- ❑ Compare this result with the analyses at watersheds in other climate regions.
- ❑ Compare more scenarios of deterministic and stochastic initial soil moisture.