A Comparison of PRISM and CFSR precipitation data effects on calibration and uncertainty of SWAT Models

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Introduction

- Precipitation is one of the most important drivers in watershed models
- A common source of precipitation data for SWAT models is the Climate Forecast System Reanalysis (CFSR) data
- This is an interpolated dataset on a 38-km grid based on the National Weather Service Global Forecast system
- Another source of interpolated daily weather data that has not been commonly used or tested in SWAT models is the Parameter-elevation Relationships on Independent Slopes Model (PRISM) data (Daly et al., 2008; Di Luzio et al., 2008) available with a grid spacing of 4 km covering the conterminous United States for the period from 1981-present

Objective

Our objective was to compare the effect of PRISM and CFSR data on the fit of a SWAT model of streamflow in the Big Haynes Creek watershed. To confirm the results, we also compared the effect on a watershed in Louisiana. To help understand the differences we found, we also looked at the effect of using the National Climate Data Center (NCDC) weather data which is not interpolated.

Study Area

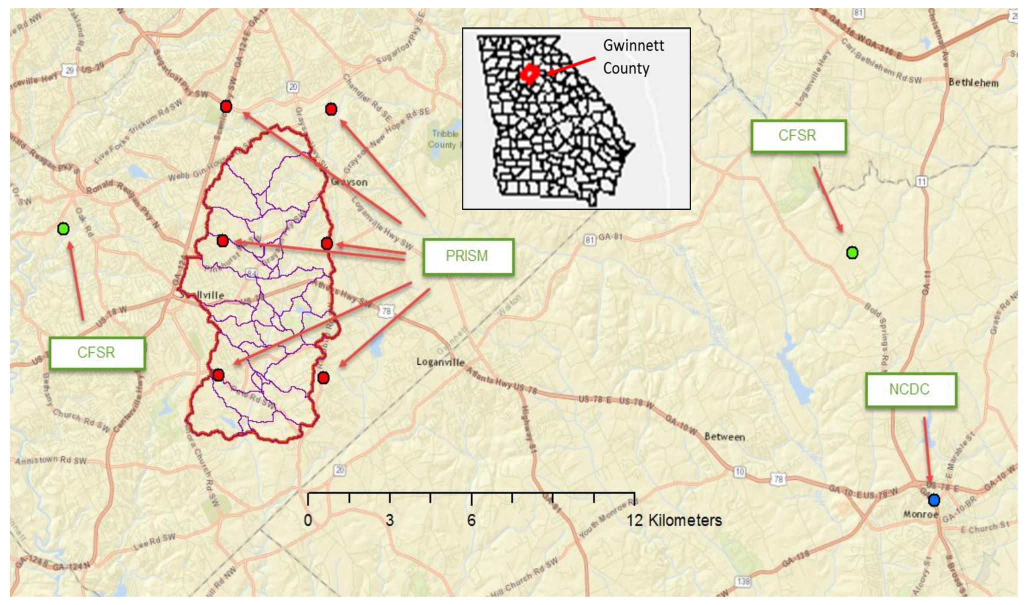

Fig. 1. Big Haynes watershed in Gwinnett County, GA, and the location of 6 PRISM interpolated weather stations (4-km grid), 2 CFSR interpolated weather stations (38-km grid), and one NCDC weather station.

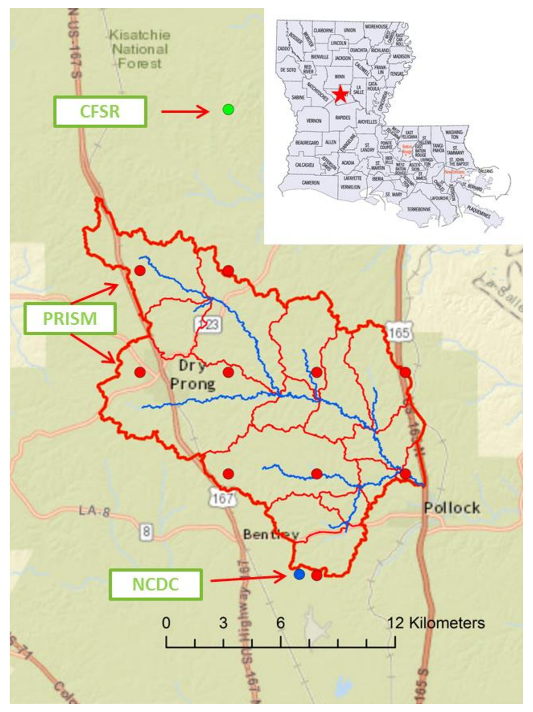

Fig. 2. Big Creek watershed in Grant County, Louisiana and location of 10 PRISM interpolated weather stations (4-km grid), one CFSR interpolated weather station (38-km grid), and one NCDC weather station.

Methods

Models

- SWAT models were developed that differed only in source of weather data: PRISM, CFSR, or NCDC
- Models were run with 4 years warm up, 4 years calibration, and 4 years validation
- SWAT-CUP was used for calibration, starting with 22 parameters, and 1,000 runs per iteration
- Ended with 10-12 calibrated parameters

Georgia

- 44.7 km^2 watershed was 58% urban, 25% forest, 10% agricultural (Fig. 1)
- USGS gage station provided daily flow at outlet
- Used 6 PRISM interpolated stations, 1 CFSR interpolated station (4 km from watershed), or 1 NCDC gage station (20 km from watershed)
- Calibration 1/1/2003 – 12/3/2006, validation 1/1/2007 – 12/31/2010
- SUFI-2 used for calibration

Louisiana

- 132 km^2 watershed was 85% forest, 10% wetland, 5% range/hay (Fig. 2)
- USGS gage station provided daily flow at outlet
- Used 10 PRISM interpolated stations, 1 CFSR interpolated station (7 km from watershed), or 1 NCDC gage station (at watershed boundary)
- Calibration 1/1/2003 – 12/3/2006, validation 1/1/2007 – 12/31/2010
- PARASOL used for calibration
- Ended with 12-17 calibrated parameters

Results

Table 1. Fitting criteria for calibration and validation runs of the Big Haynes Creek watershed in GA and the Big Creek watershed in LA.

Criteria	Data	Big Haynes Creek, GA		Big Creek, LA	
		Calibration	Validation	Calibration	Validation
NSE	PRISM	0.66	0.69	0.90	0.73
	CFSR	0.45	0.51	0.37	0.28
	NCDC	0.36	0.50	0.75	0.63
p-factor	PRISM	0.72	0.36	0.22	0.27
	CFSR	0.75	0.72	0.23	0.29
	NCDC	0.44	0.66	0.46	0.51
r-factor	PRISM	0.27	0.28	0.08	0.08
	CFSR	0.52	0.46	0.09	0.10
	NCDC	0.32	0.45	0.19	0.21

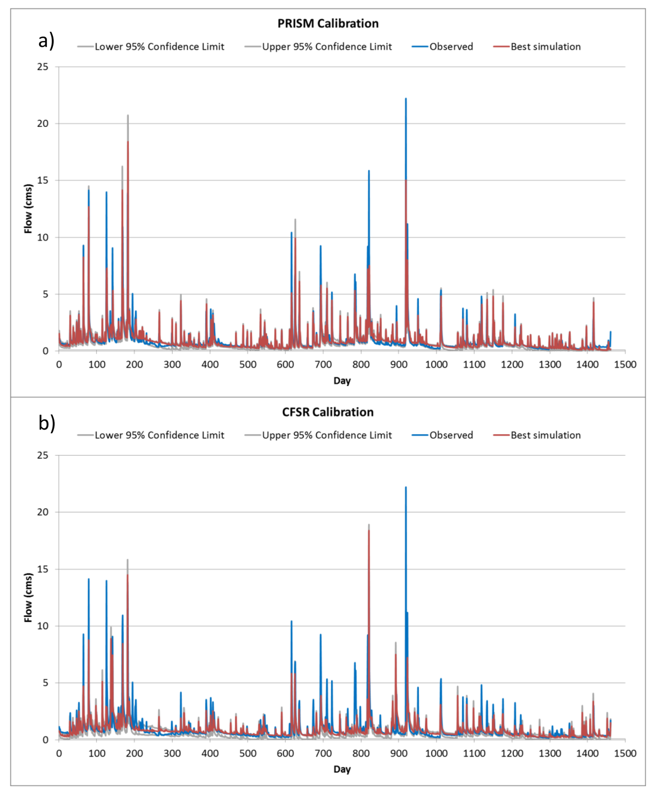

Fig 3. PRISM (a) and CFSR (b) SWAT simulations for the full calibration period (1/1/2003 to 12/31/2006) and observed data for Big Haynes Creek in GA.

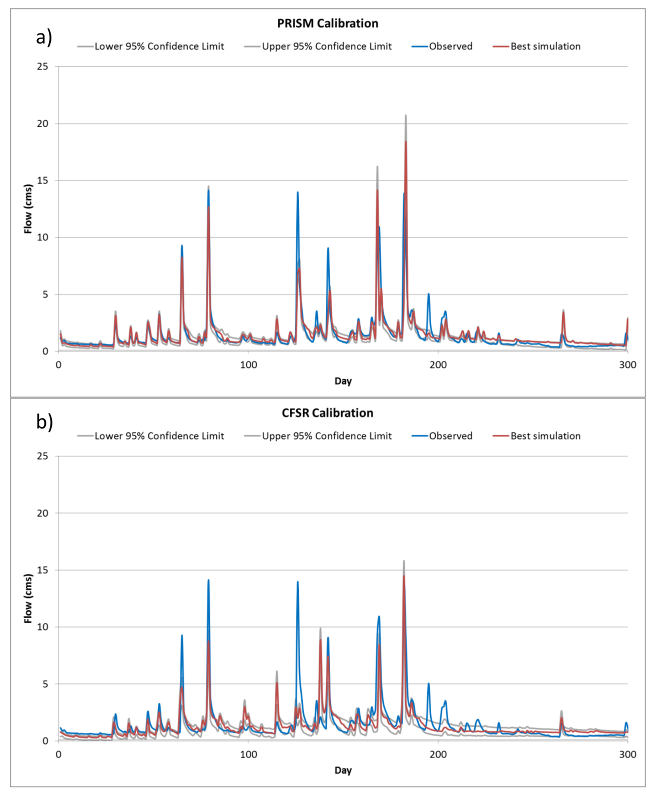

Fig. 4. PRISM (a) and CFSR (b) SWAT simulations for the first 300 days of the calibration period and observed data for Big Haynes Creek in GA.

Results

Table 2. SWAT parameter definitions and calibrated values for CFSR and PRISM simulations in Big Haynes Creek watershed in GA. Simulations resulted in a similar list of parameters and values except for GW_DELAY, GW_QMIN, and SOL_K. Calibrated values resulted in more rapid recharge of shallow aquifer and groundwater stream response with PRISM. Results were similar in LA.

Parameters	Units		CFSR	PRISM
CH_K1	mm/h	Ephemeral channel saturated hydraulic conductivity	328	326
CH_K2	mm/h	Main channel saturated hydraulic conductivity	25	16
CH_N2	-	Main channel Manning's value	0.05	0.02
CN2	-	Moisture condition II curve number	-0.09*	-0.10*
GW_DELAY	day	Delay time for aquifer recharge	297	64
GW_QMN	mm	Threshold water level for aquifer discharge to stream	471	133
GW_REVAP	-	Groundwater ET coefficient	0.05	0.06
RES_RR	m^3/s	Reservoir average daily principal spillway release rate	1.69*	1.71*
REVAPMN	mm	Threshold water level for groundwater ET	207	194
TRNSRCH	-	Fraction of transmission losses to deep aquifer	0.005	0.004
RES_EVOL	10^4 m^3	Reservoir volume when filled to emergency spillway		0.27*
SOL_K	mm/h	Soil saturated hydraulic conductivity		0.51*

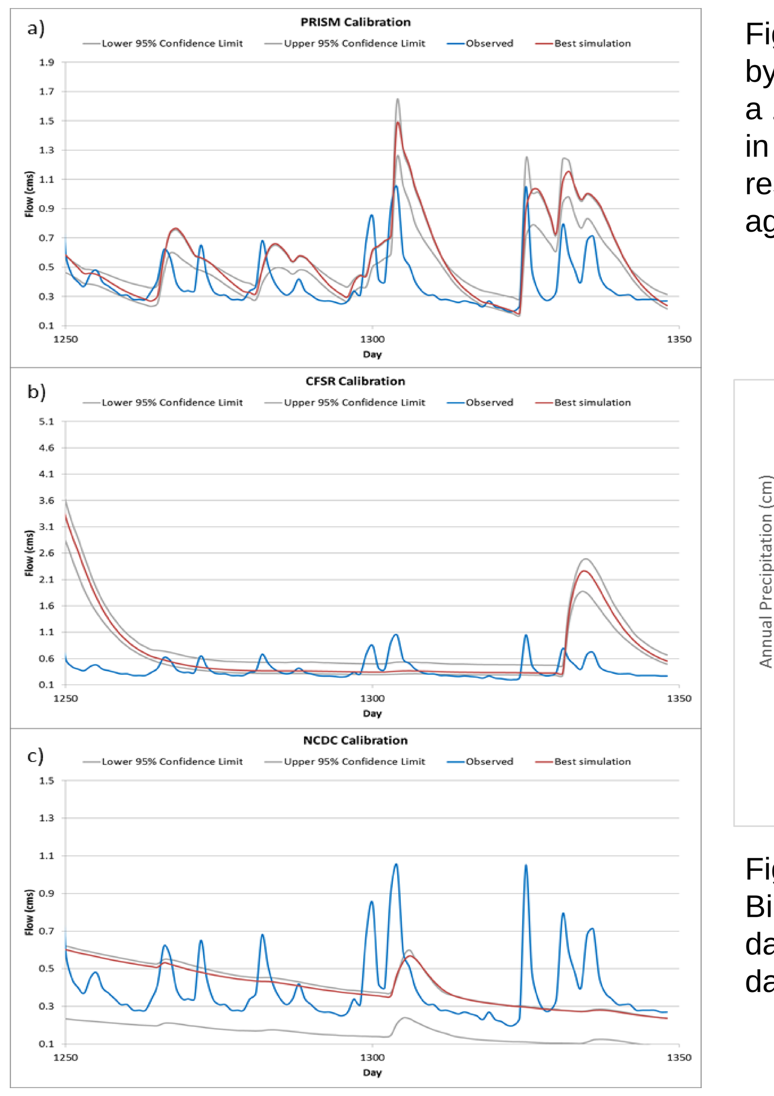

Fig 5.Comparison of streamflow simulated by a) PRISM, b) NCDC, and c) CFSR during a 100-day period in the Big Creek watershed in LA. PRISM simulation showed a more responsive groundwater system and better agreement with observed data.

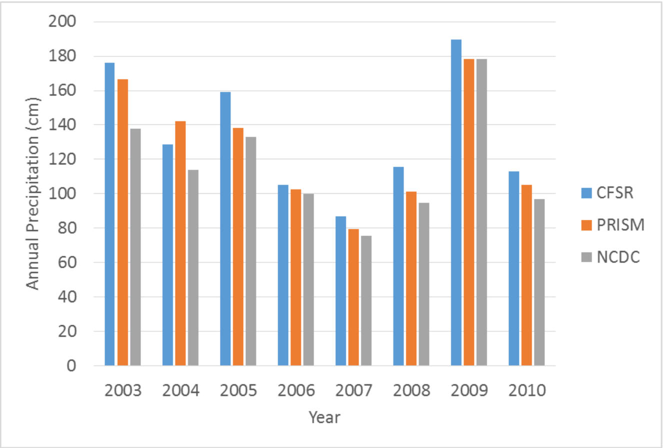

Fig 6. Annual rainfall calculated in SWAT for Big Haynes Creek in GA. PRISM and NCDC data resulted in lower totals than CFSR data.

Conclusion

- We compared PRISM and CFSR interpolated climate data in SWAT models in 2 watersheds in the southern US
- In both locations PRISM data outperformed CFSR in simulating high and low flow periods
- The calibrated model using PRISM data resulted in a more responsive groundwater system in both watersheds
- PRISM models also outperformed models using NCDC gage data but the rain gages were outside the watersheds
- Scatter plots comparing CFSR and PRISM precipitation data showed that there was little agreement between estimated values (R^2 = 0.15)
- If the CFSR data was delayed by one day, the agreement was better and the fitted line was closer to the 1:1 line in the scatter plots (R^2 = 0.36)
- Model predictions of storms using CFSR data tended to precede the observed storm
- Overall, PRISM seemed to provide a better estimate of precipitation than CFSR resulting in more accurate simulations of stormflow
- Further testing comparing PRISM and CFSR data sets in other watersheds is needed