Basins-Level Heavy Rainfall and Flood Analyses

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Submitted to *Advances in Meteorology as* "Flood Simulation in South Carolina Watersheds Using Different Precipitation Inputs"

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Introduction: Flooding

- The most frequently occurring and costly natural hazards
- Heavy rainfall and flooding in South Carolina
  - Hurricane Joaquin October 2015
  - Hurricane Matthew in October 2016
- Hydrological models for mitigation of impacts
- Spatial and temporal accuracy of rainfall data influence the performance of hydrological models

Introduction: Rainfall Data Sources

- Rain gauge observations
  - Accuracy
  - Long time coverage
  - Poor representation of areal precipitation
  - Temporal resolution

- Radar
  - A better capture of precipitation over spatial and temporal scales
  - Temporal coverage: 2002 to present

Objective

- Assess suitability of different precipitation data sources in the flood simulation using HEC-HMS (Hydrologic Engineering Center's Hydrologic Modeling System)
- Test the effectiveness of the new method that integrates merits of precipitation gauge data and the widely used gridded daily PRISM data (Parameter-elevation Relationships on Independent Slopes Model)

Precipitation Inputs

- Hourly rainfall station data → *Point-based representation of precipitation*
- Hourly radar data
- Blended rainfall station and PRISM data

  (Hourly radar data and Blended rainfall station and PRISM data) → *Area-based representation of precipitation*

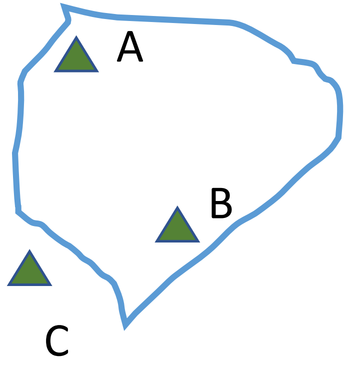
  - PRISM: daily total precipitation in the continental United States from 1981 to present

PRISM: Parameter-elevation Relationships on Independent Slopes Model

Integration of Station and PRISM data

Hourly Precipitation of Candidate Stations

Hour	A	B	C
00:00	1	1	1
01:00	1	2	1
02:00	0	1	2
03:00	1	2	2
….	….	….	….
20:00	0	1	1
21:00	0	0	0
22:00	2	1	2
23:00	0	0	2
Daily Total	5	8	11

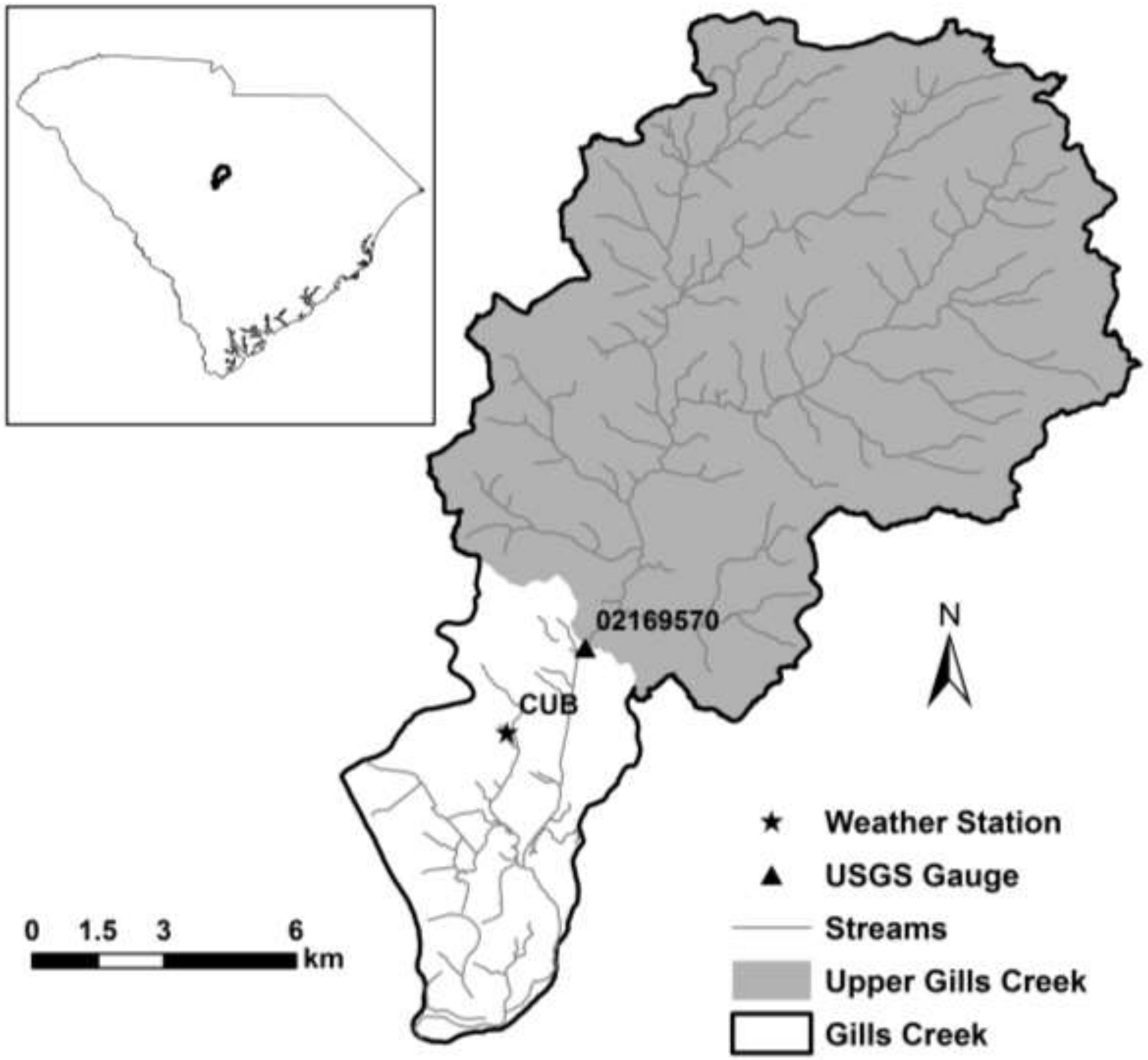


PRISM daily total of the watershed: 6

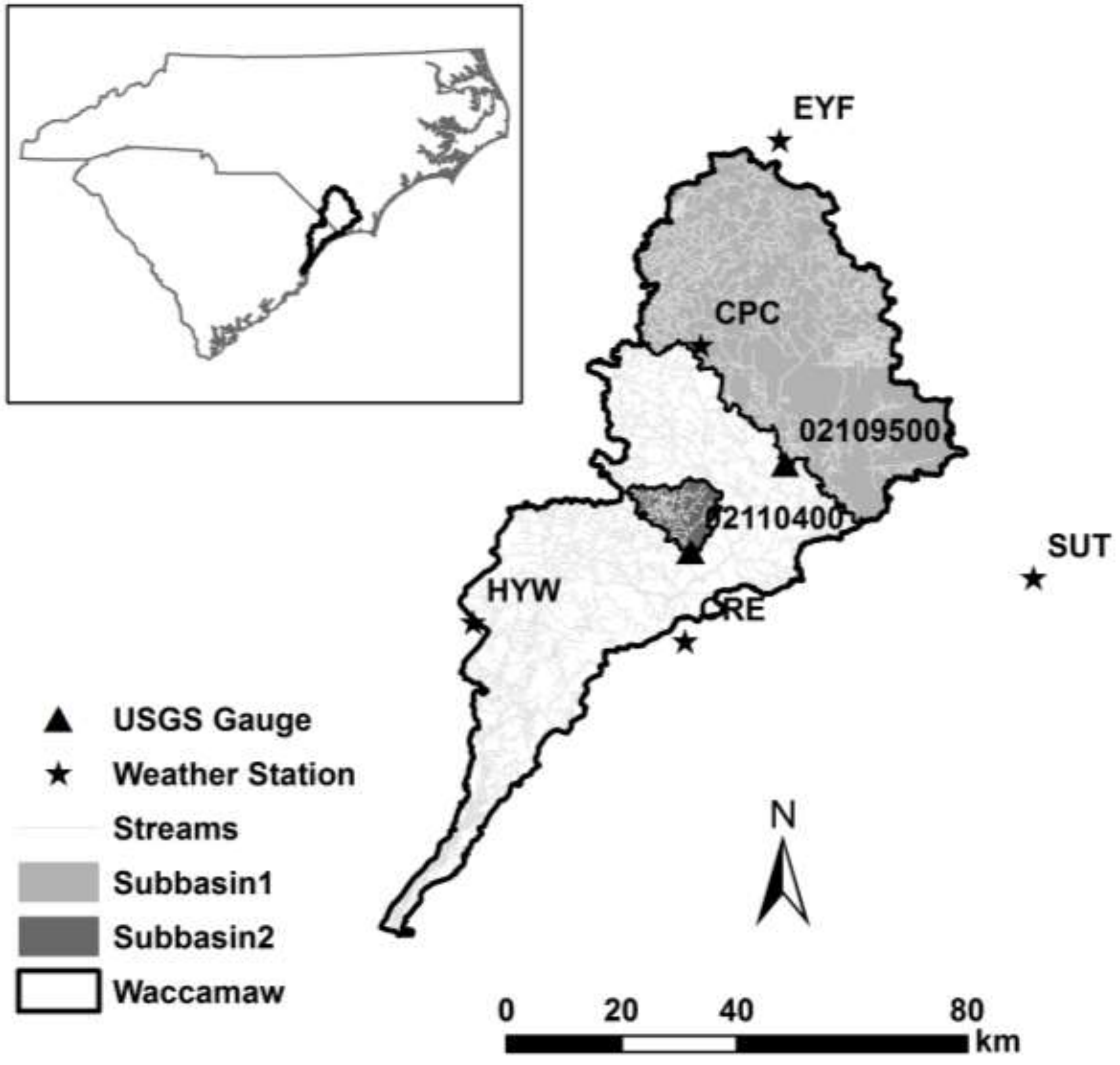
PRISM: Parameter-elevation Relationships on Independent Slopes Model

A		Adjusted A
1		1.2
1		1.2
0		0
1	$\times\frac{6}{5}$ →	1.2
….		….
0		0
0		0
2		2.4
0		0
5		6

Study Area



Gills Creek



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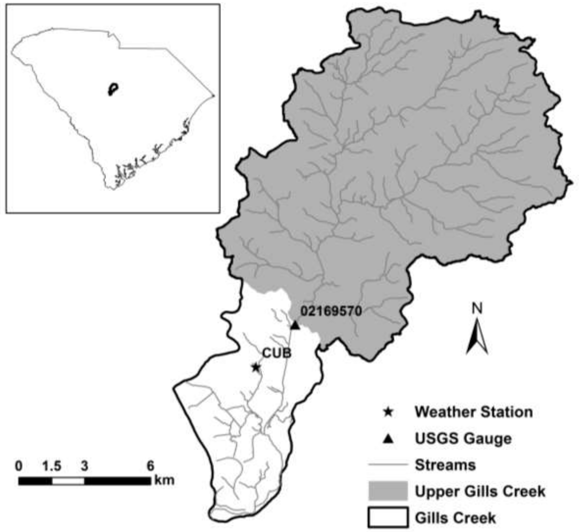
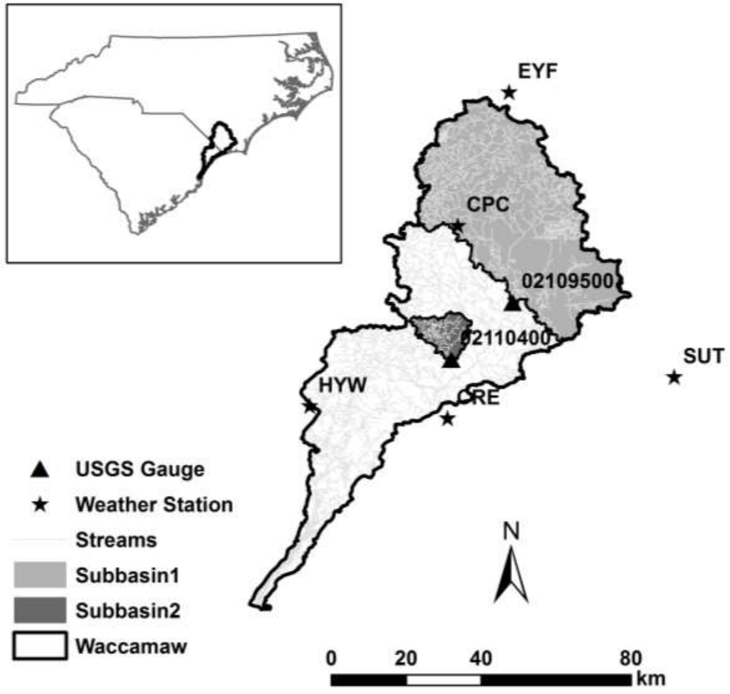
Model Simulation

	Time Period	Highest Daily Flow (ft^3s^{-1})	Date	Exceedance (%)
Calibration	01/09/2014 22:00 to 01/11/2014 12:00	656	1/11/2014	99.65
Testing 1	12/23/2014 11:00 to 12/25/2014 23:00	652	12/24/2014	99.64
Testing 2	09/22/2011 07:00 to 09/24/2011 06:00	661	9/23/2011	99.66





		Time Period	Highest Daily Flow (ft^3s^{-1})	Date	Exceedance (%)
Subbasin 1	Calibration	02/03/2016 00:00 to 02/15/2016 23:00	7350	2/10/2016	99.78
	Testing 1	10/02/2015 12:00 to 10/11/2015 23:00	10900	10/8/2015	99.94
	Testing 2	09/14/1999 00:00 to 09/25/1999 23:00	30600	9/21/1999	100.00
Subbasin 2	Calibration	02/03/2016 00:00 to 02/15/2016 23:00	1390	2/5/2016	99.83
	Testing 1	10/02/2015 12:00 to 10/11/2015 23:00	2750	10/5/2015	100.00

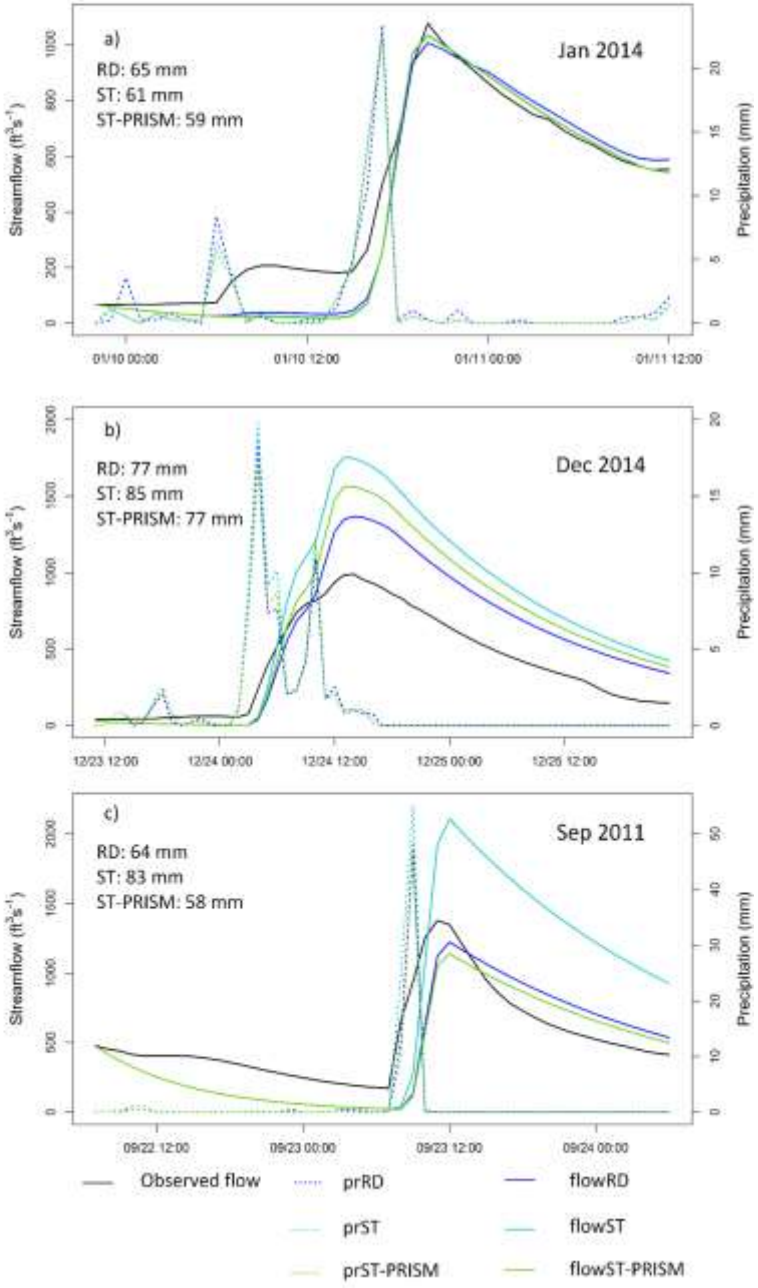
Model Simulation

- HEC-HMS was calibrated separately using point-based representation (i.e., station data) and two area-based representations of precipitation (i.e., radar, and blended station and PRISM data), which yielded a set of parameters for *each* of the three precipitation inputs
- In the testing periods, flood simulation was conducted using the three calibrated models with the same precipitation inputs used to calibrate the models

PRISM: Parameter-elevation Relationships on Independent Slopes Model
HEC-HMS: Hydrologic Engineering Center's Hydrologic Modeling System

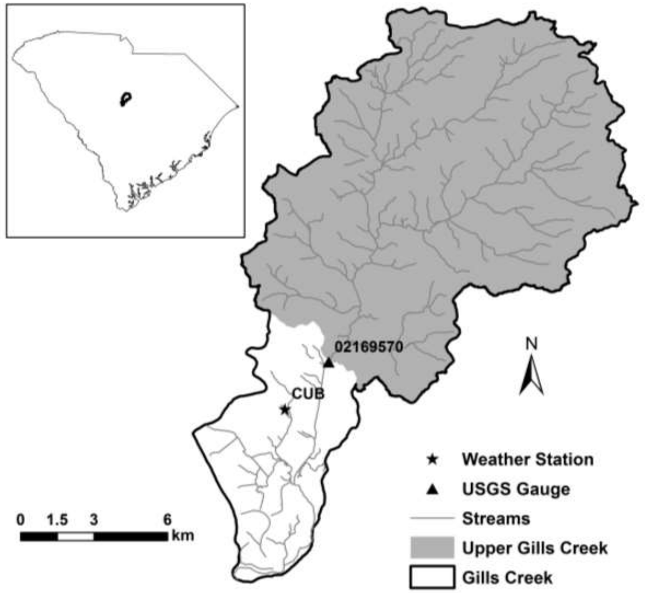
Calibration

Testing



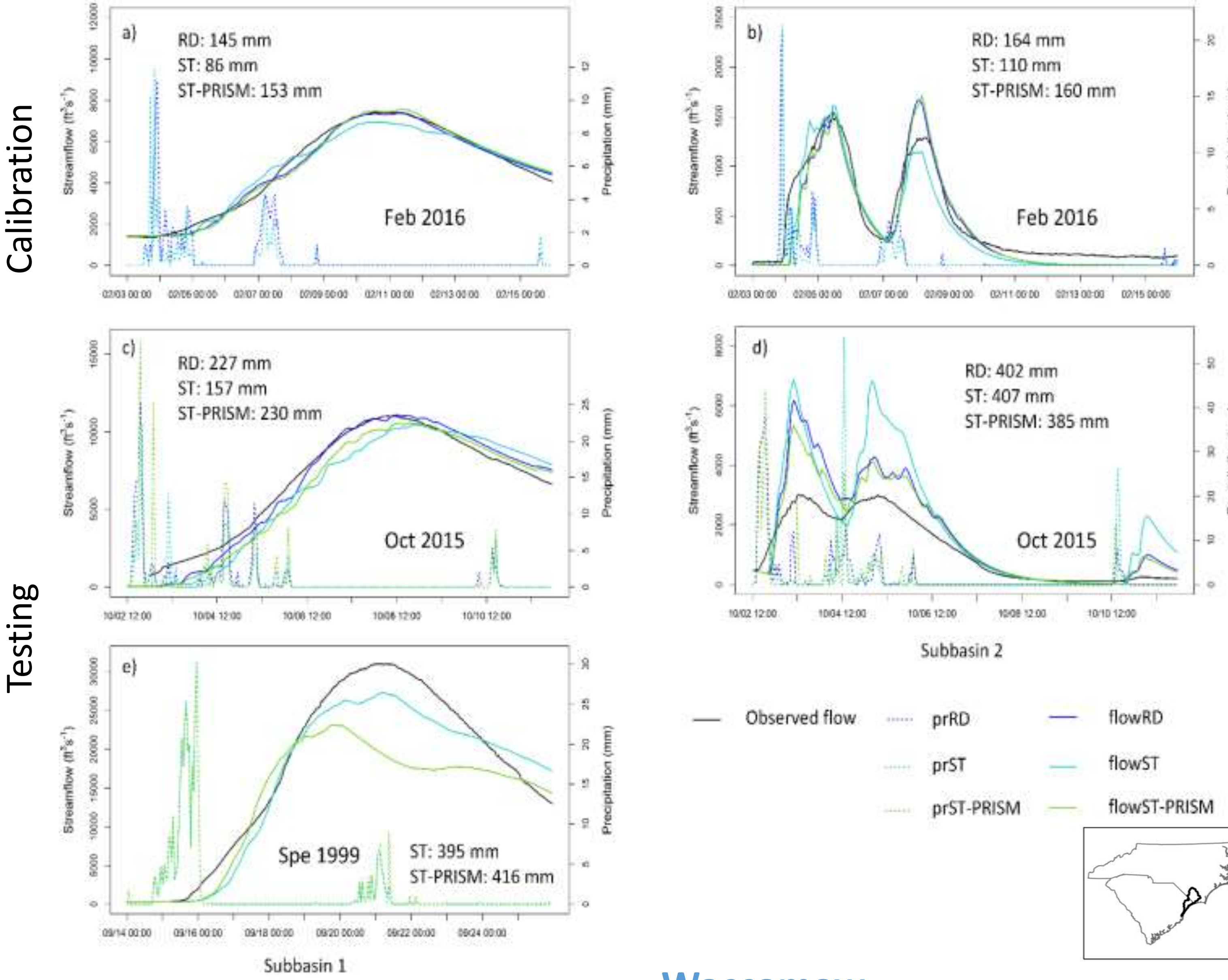
Gills Creek

- Total amount precipitation
  - Three types of precipitation input are similar
- Model Performance
  - Area-based representation (RD and ST-PRISM) better than ST



ST: station data; RD: radar data

ST-PRISM: blended station and PRISM data



- Total amount precipitation
  - Large difference between area-based and point-based representation of precipitation
  - *potential retention scale factor* was particularly set to an extremely low value to reduce the loss of rainfall
- Model Performance
  - Area-based representation (RD and ST-PRISM) better than point-based (ST)

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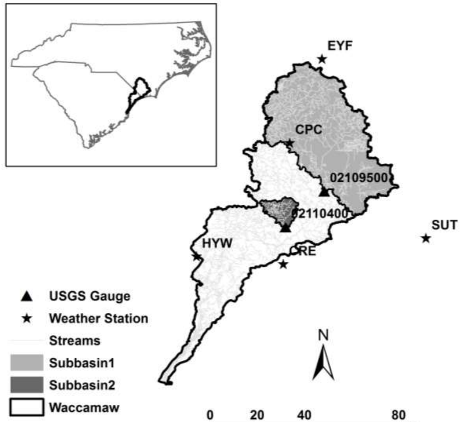

ST: station data; RD: radar data

ST-PRISM: blended station and PRISM data

Discussion

- the importance of spatial representation of precipitation for flood simulation
  - observations at a single station led to unreliable flood simulation (the calibrated parameter does not realistic hydrological processes)
  - models calibrated by the two areal representations of precipitation had similar performance -- better than the model calibrated by a single station

Discussion

- Ways of converting gauge observations into areal representation of precipitation
  - Spatial interpolation
    - adequate density of rain gauges
  - blended station and PRISM data
    - extends the data availably prior to 2002
    - useful when the density of rain gauges is too low to perform spatial interpolation

Acknowledgements

- This research is supported by the Advanced Support for Innovative Research Excellence (ASPIRE) I, Track 2B, from the Office of the Vice President for Research, University of South Carolina and the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office (grant no. NA16OAR4310163) to the Carolinas Integrated Sciences and Assessments (CISA).

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