Ensemble Error Propagation of Satellite Rainfall Estimate in Multi-Scale Basin Flow Simulations

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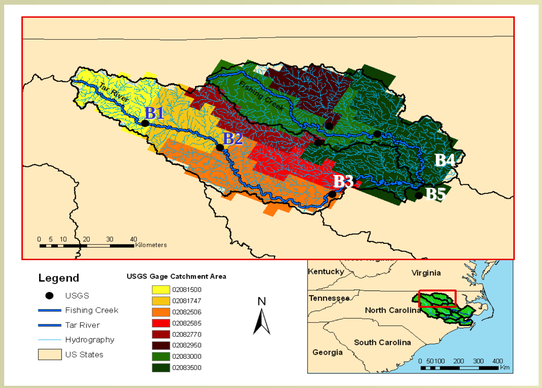
Summary, Study Area, Modeling

SUMMARY

Propagation of satellite rain ensembles from three global datasets (3B42 RT, CMORPH, PERSIANN) through a conceptual model for river flow simulations evaluated for a cascade of basin scales of the Tarboro basin based on a 2-year record (2004 and 2006) and Stage IV rainfall products used as reference. Satellite rainfall error ensembles are based on a stochastic satellite rainfall error model calibrated over the Southeast US region.

STUDY AREA: Tarboro sub-basin of Tar basin, SE USA



Basin scales:

B1: 529 km^2

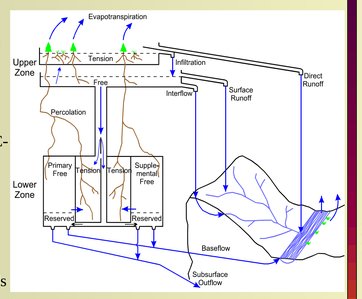
B2: 1069 km^2

B3: 1981 km^2

B4: 2364 km^2

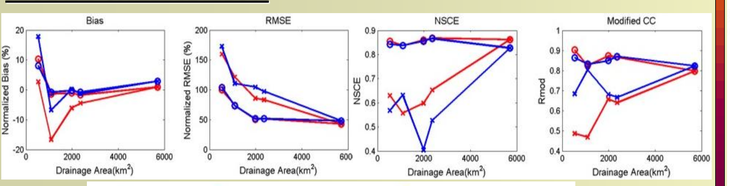
B5: 5709 km^2

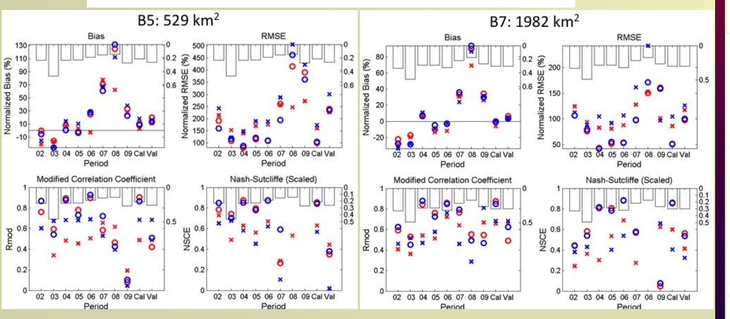
HYDROLOGIC MODEL



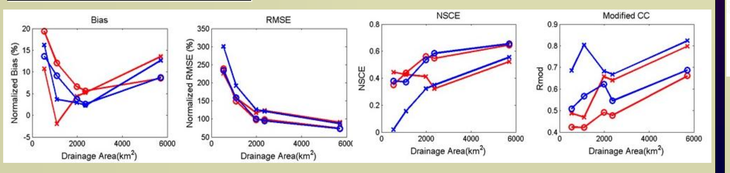
- Hydrology Laboratory – Research Distributed Hydrologic Model by NWS (HL-RDHM).
- Hybrid Conceptual – physical distributed watershed model:
  - Sacramento Soil Moisture Accounting model (SAC-SMA)
  - Kinematic Wave Model
- SAC-SMA consists of 17 parameters
  - 6 No gridded parameters ➔ Default Value
  - 11 gridded parameters ➔ a-priori (Victor Koren)
  - Climatological Monthly Potential Evaporation grids
- Routing technique consists of 5 gridded parameters
  - Only 2 of them are considered in this study
  - Derived from historical Q – A relationship at USGS stations (rating curve).
- HL-RDHM works with gridded data at HRAP resolution (or ½ HRAP, ¼ HRAP)
  - Hydrologic Rainfall Analysis Project (HRAP) is a grid used in NWS.
  - HRAP ≈ 4.7 km
- A-priori Estimates for SAC-SMA Parameters
  - Model's storage components are related to soil hydraulic properties (wilting point, field capacity, porosity, and soil profile depth).
  - Koren's a-priori estimation implements a combination of physically-based and empirically-derived relationships.
  - The a-priori estimation for the 11 SAC-SMA parameters were derived by using State Soil Geographic (STATSGO) soil data.
- Default values for the remaining 6 SAC-SMA are from previous NWS experience on different basins.

MODEL CALIBRATION





MODEL VALIDATION

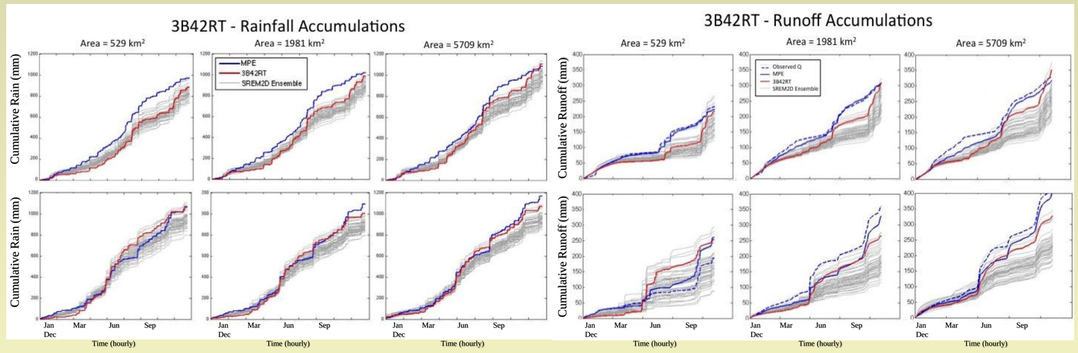


CONCLUSIONS ON MODELING UNCERTAINTY

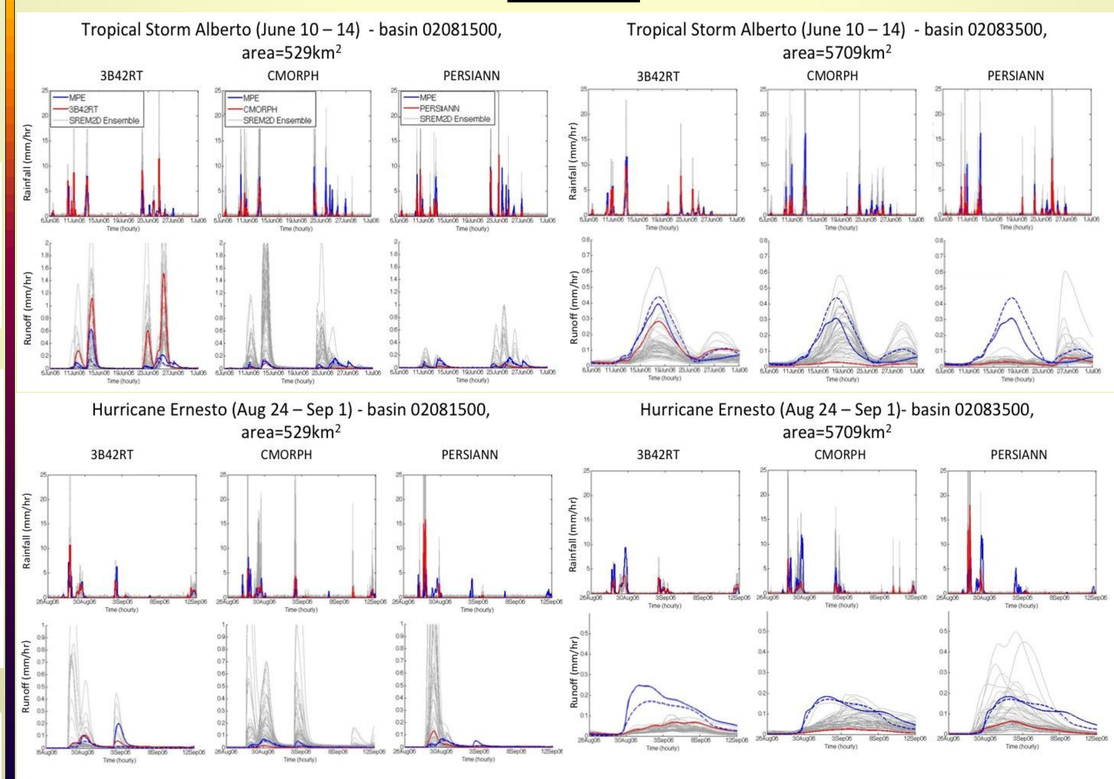
- After calibration model error characteristics at two spatial scales are similar
- Model performance with local calibration is superior to model performance with regional calibration; this effect is more significant at smaller basin scales.
- There is significant year-to-year variability on model performances using local calibration; wet years tend to exhibit better performances; less yearly variability is exhibited for the regional model calibration performance

Rainfall and Runoff Time Series

Cumulative time series



Time series

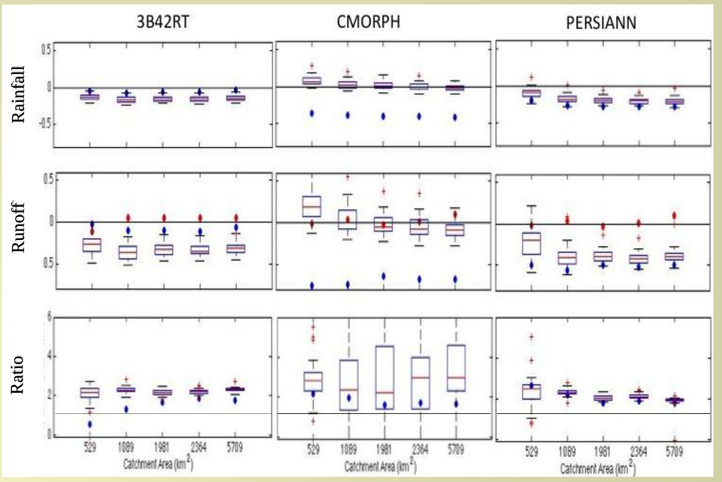


CONCLUSIONS ON ERROR PROPAGATION

- Bias doubles from rainfall to runoff and this increase is consistent across all basin scales and the three retrievals examined in this study; the CMORPH error analysis shows significant variability around this rainfall-to-runoff bias increase.
- The runoff to rainfall random error ratio decreases as function of catchment area consistently for all ensembles to about 0.5 for PERSIANN and CMORPH and 0.8 for 3B42RT

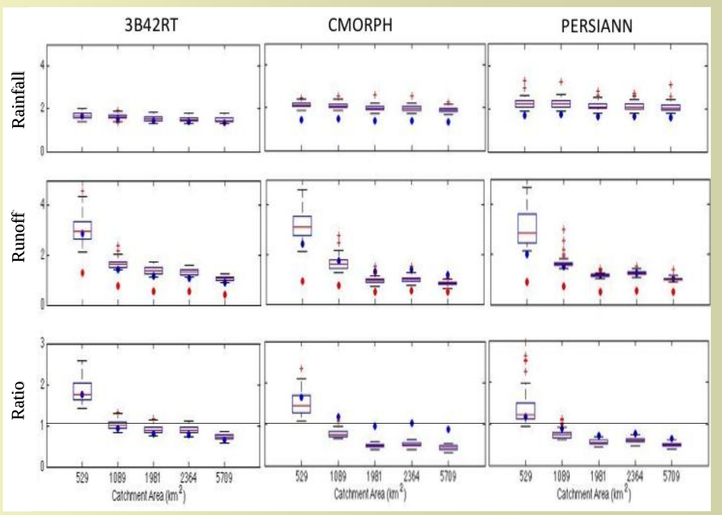
Rainfall – Runoff Error Propagation Analysis

Relative Bias vs. basin scale



- Model Error (Simulated Q vs. Observed Q)
- Reference Statistic (Satellite vs. MPE)

Relative RMSE vs. basin scale



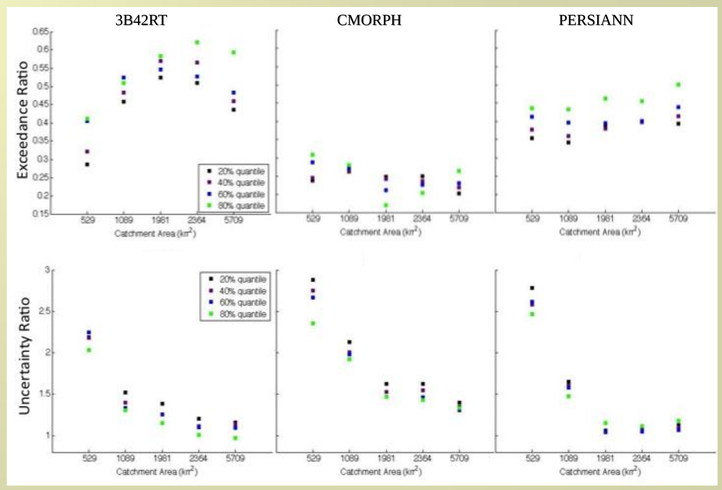
Runoff Exceedance/Uncertainty Ratio vs. basin scale

Uncertainty Ratio: ensemble width normalized by reference values

$$ER = \frac{N_{ex\,c}}{N_t}$$

Exceedance ratio: frequency that reference values exceed the ensembles envelope

$$UR = \frac{\sum_{i=1}^{N_t} \left(\hat{\vartheta}^i_{up\,lp} - \hat{\vartheta}^i_{o\,lw} \right)}{\sum_{i=1}^{N_t} \vartheta^i}$$



CONCLUSIONS ON ERROR PROPAGATION (cont.)

- The CMORPH ensembles exhibited the lowest exceedance ration compared to the other two retrievals for all catchment area examined in this study.
- The uncertainty ratios that represent the ensemble with generated by SREM2D exponentially decrease with basin scale for all three retrievals; CMORPH exhibited slightly higher uncertainty ratios compared to the other two retrievals.