

Improving Hydrologic Model Predictions: Role of Multi-model Combinations

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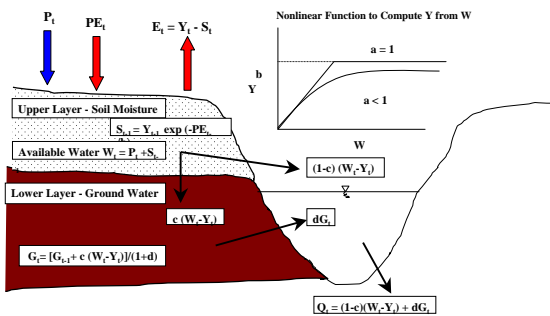
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OUTLINE

1. Model Selection and Multimodel algorithm
2. Experimental Design
3. Analysis of the algorithm and Results
4. Application – Watershed Modeling and Streamflow Prediction
5. Summary & Conclusion

MODEL SELECTION

- 'abcd' Water Balance Model (Thomas et al., 1981)



MODEL SELECTION

- 'VIC' (variable infiltration capacity) model

Calibration method

- OLS (ordinary least square): the objective of the model calibration is to

$$\text{Minimize } \sum_{i=1}^n (Q'_i - Q''_i)^2$$

- ABS (absolute value of difference): in this case, the objective of the model calibration is to

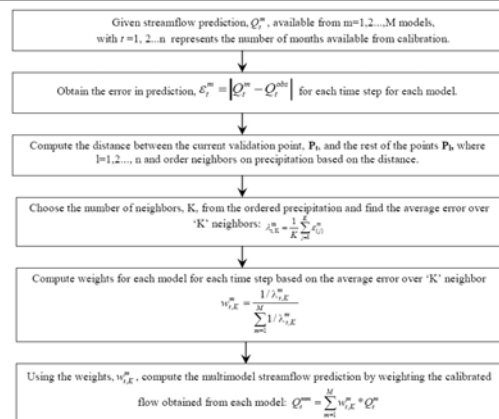
$$\text{Minimize } \sum_{i=1}^n |Q'_i - Q''_i|$$

Where Q'_i and Q''_i are the observed and modeled streamflow, respectively.

Multimodel algorithm

Single models

- Applied these two calibration method, a total number of 4 single models were developed
- 'abcd' OLS, 'abcd' ABS, 'VIC' OLS and 'VIC' ABS.
- Input – Precipitation, PET
- Output – Streamflow
- The steps in Multi-model combination is described as the following table.



Experimental Design

Concept of “true” model

- The calibration using the predicted Q from that single model should give the true parameters and 0 errors in theory.

Adding “noise” to the model

- Errors(noise) was added to test the applicability of the algorithm in all the flow conditions.
- Noise Factor f_2 takes the value from 0 to 1.5.
- “Noise” follows normal distribution with mean of 0 and standard deviation of $f_2\sigma_Q$

Generating streamflow that contains the ‘noise’

- Mathematical representation of the ‘noise’:

$$Error_t = NORMINV(Random(), 0, f_2\sigma_Q)$$
- Generating streamflow:

$$Q_{gen,t} = Q_{est,t} + Error_t \text{ if } Q_{gen,t} < 0, \text{ make } Q_{gen,t} = 0$$

Model combinations

- Split the dataset into training & validation period
- Calibrate the 4 single model using Q_{gen} , at each noise levels.
- Combine the single model predictions using the algorithm and get the multi-model predictions

Results

“abcd” model as “true” model

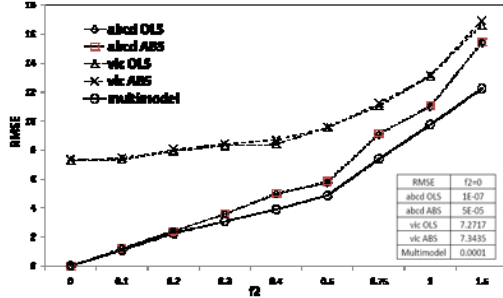


Figure 1. RMSE under different noise levels for abcd model as true model

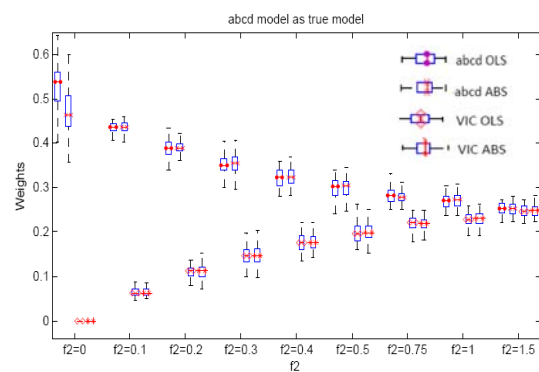


Figure 2. Weights for each single model under different noise levels

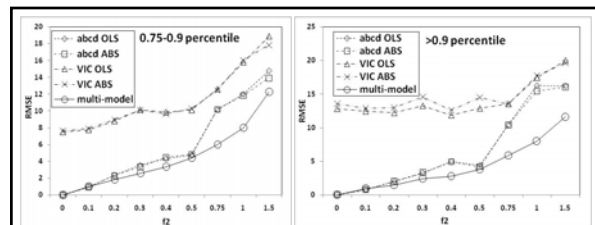
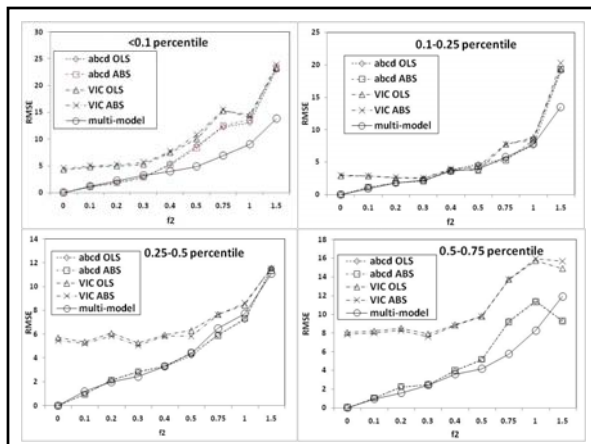
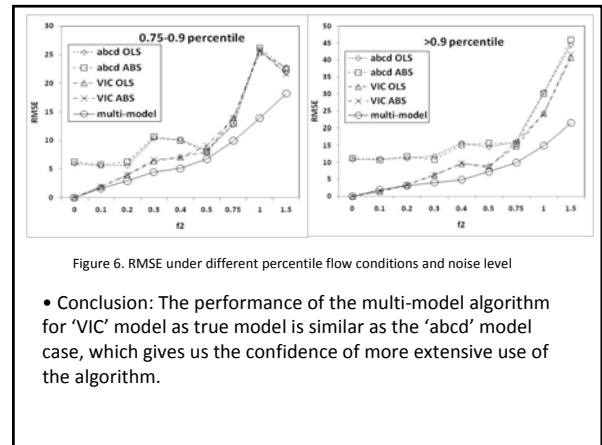
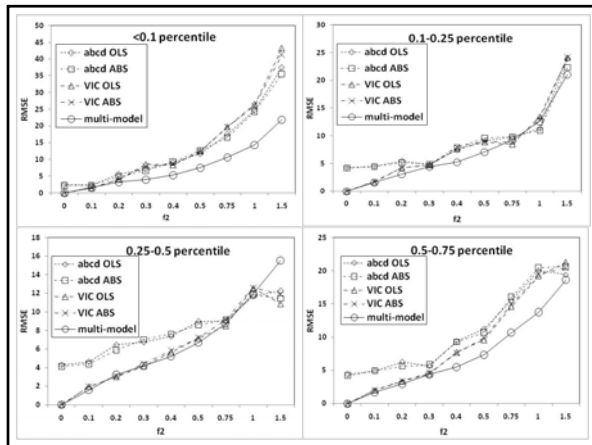
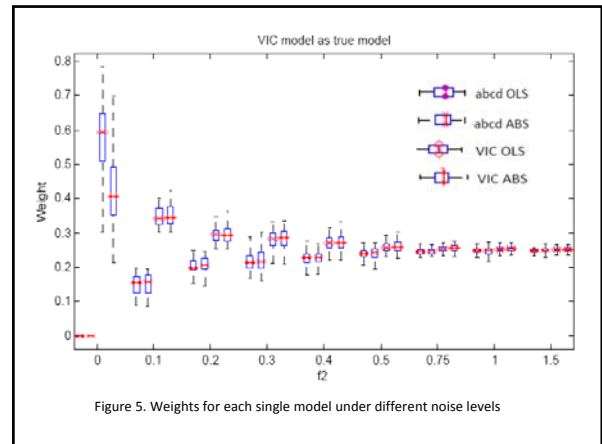
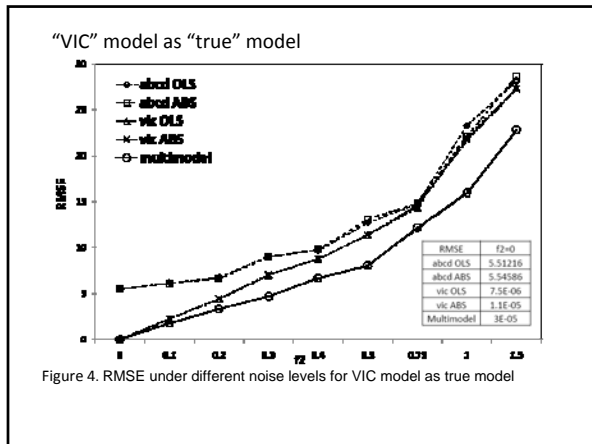


Figure 3. RMSE under different percentile flow conditions and noise level

- Conclusion: As demonstrated from Figure 1, 2 and 3, multi-model algorithm have the merits of more skillful and reliable predictions in terms of RMSE under most of the flow conditions.



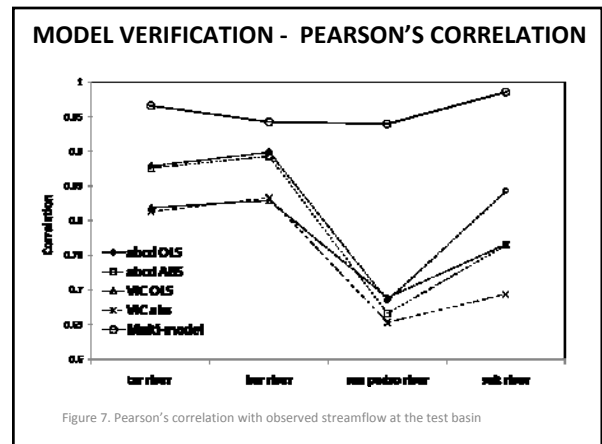
• Conclusion: The performance of the multi-model algorithm for 'VIC' model as true model is similar as the 'abcd' model case, which gives us the confidence of more extensive use of the algorithm.

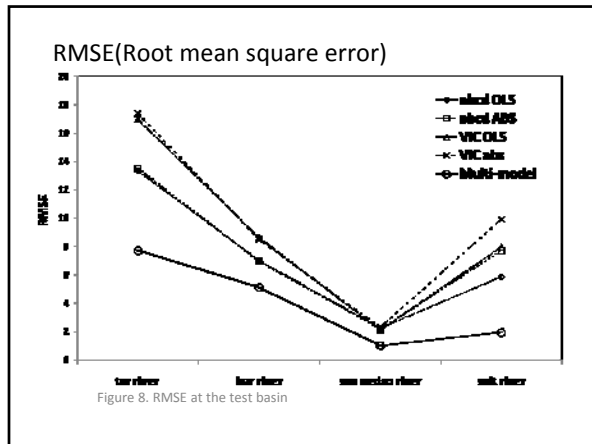
Application to the watershed.

- Based on the success of the experimental design and the results from Section 3, we have the confidence to apply the algorithm for the real basin. Therefore, four sites from the HCDN network were selected to test the algorithm.

Table 1. Geophysical and Climate characteristics of the test basin

	Basin name			
	Tar rive	Haw rive	San pedro river	Salt rive
Location	tarboro,NC	near benaja,NC	charleston,AZ	near roosevelt,AZ
Area, km ²	5588.5	430.08	3120.64	11023.36
Ann. Precip,mm	1117.6	1066.8	419.1	558.8
Data period	10/1952-9/1988	10/1952-9/1971	10/1952-9/1988	10/1952-9/1988
Training period	10/1952-9/1976	10/1952-9/1961	10/1952-9/1976	10/1952-9/1976
Validation period	10/1977-9/1988	10/1962-9/1971	10/1977-9/1988	10/1977-9/1988





SUMMARY AND CONCLUSION

- All the models are imperfect representation of the real world process and different models have the advantage of capturing different hydrograph conditions.
- Our Multi-model algorithm, has shown to be a useful and applicable scheme that combines different single model predictions and overall outperforms the single model.
- It is also desirable to look at the implementation of the multi-model in varied basins – Arid and Humid basins in the near future.
- Extending Multimodel combination with Data Assimilation techniques is bound to improve streamflow prediction than traditional approaches.