Improving the efficient and robust uncertainty quantification in real-time flood forecasting using Polynomial chaos expansions and ensemble Kalman filter

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1. Motivation in hydrologic flood forecasting

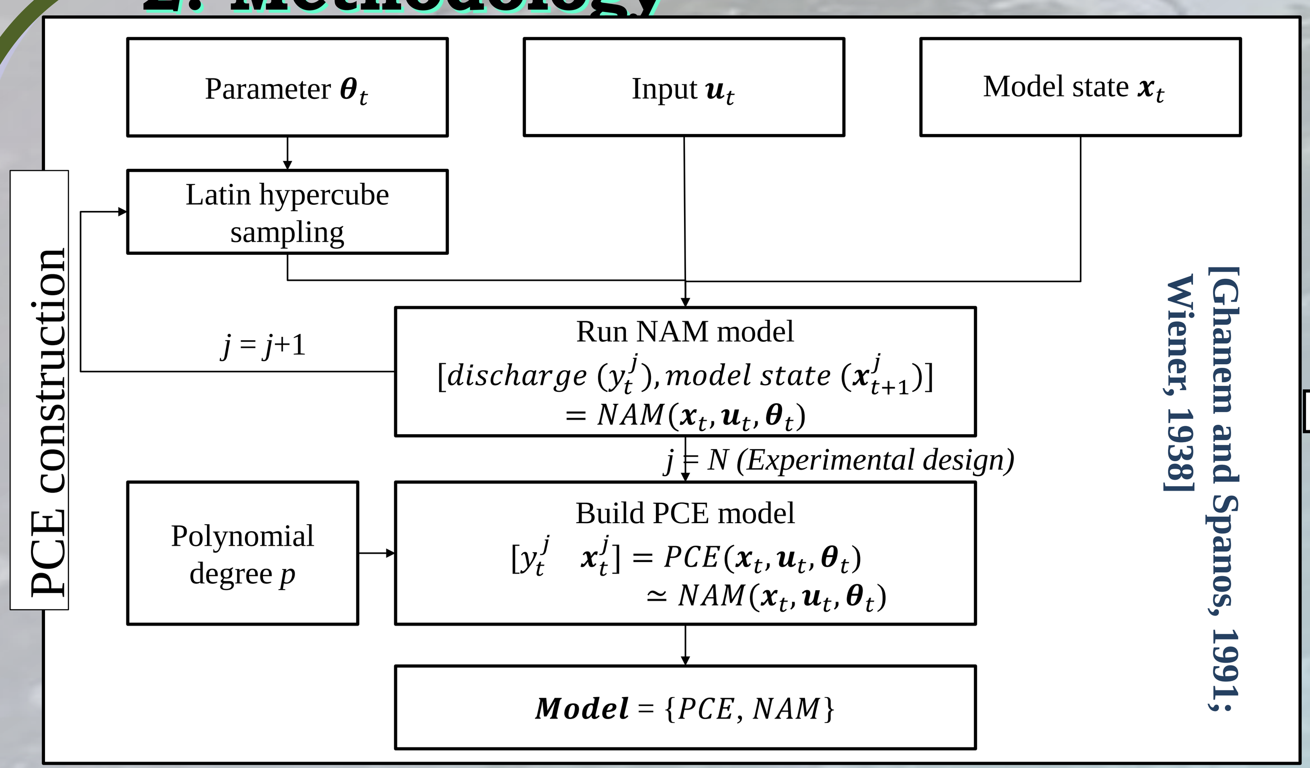
- ❑ Quantifying the uncertain ranges due to many sources is indeed important but time consuming.
- ❑ Securing sufficient (golden) time plays a significant role in terms of flood warning and risk mitigation.

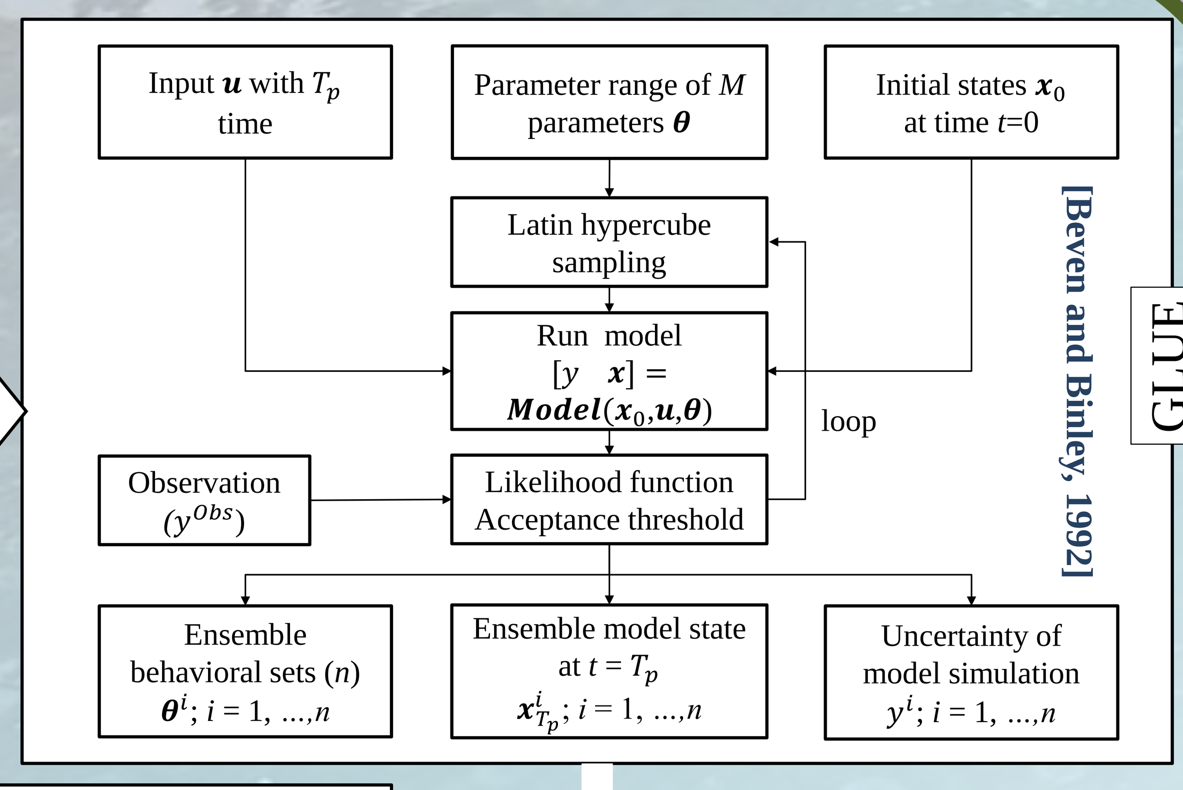
Quantifying Uncertainties vs. **Securing golden time**

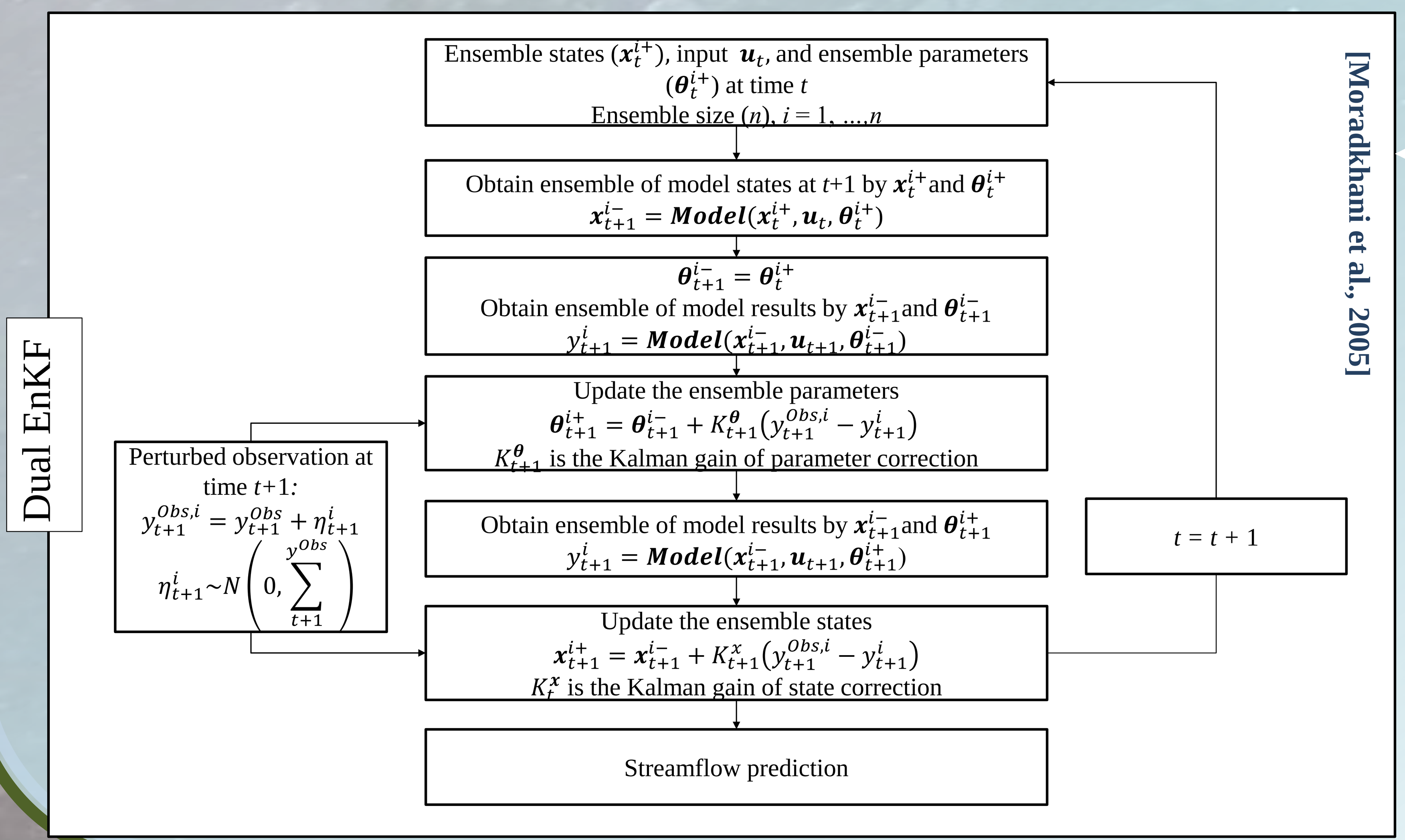
- ❑ if 30 min/run, ~5.7 years for 10^7
- ❑ if 30 sec/run, ~0.1 years for 10^7
- ❑ if 30 ms/run, ~50 min for 10^7

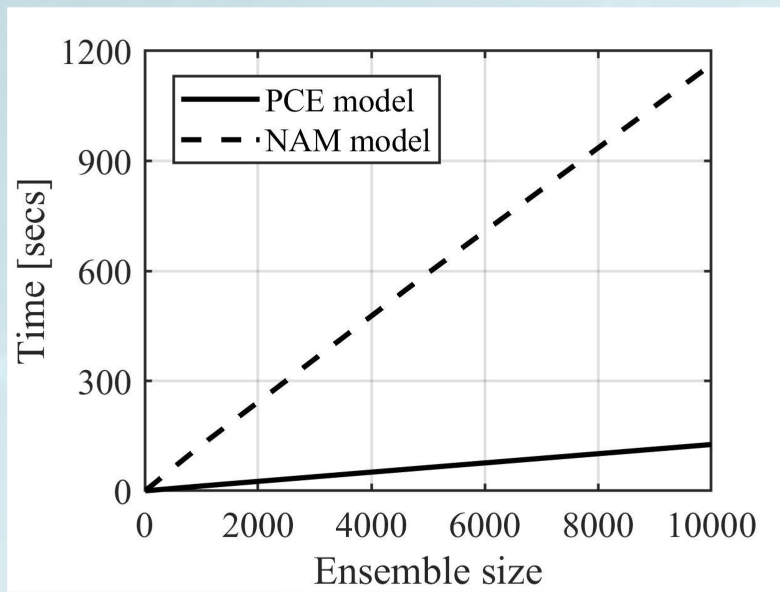
Dimension (the number of uncertain parameters)	Model runs required (10 points per dimension)	Time required in 100 cores (30 CPU minutes per simulation[1])
1	10	3 minutes
2	100	30 minutes
3	1 000	5 hours
4	10 000	~2 days
7	10 000 000	~5.7 years

2. Methodology





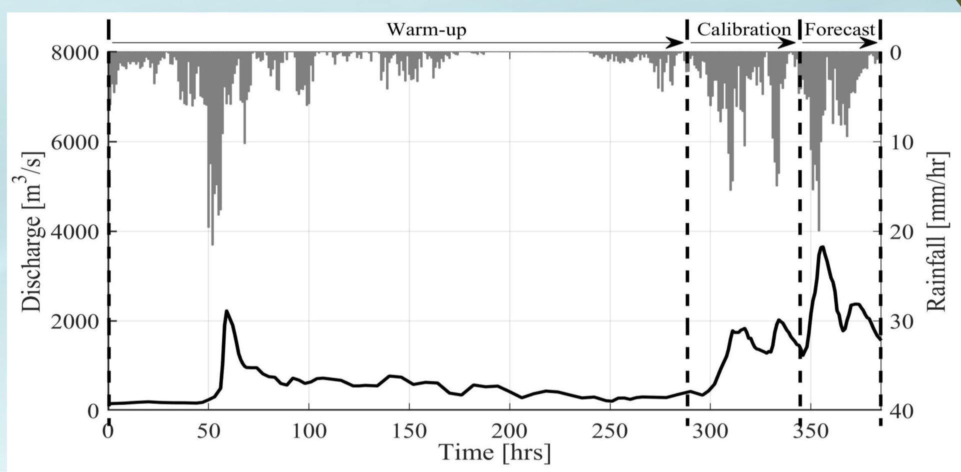




The comparison of the executed time between NAM and PCE model

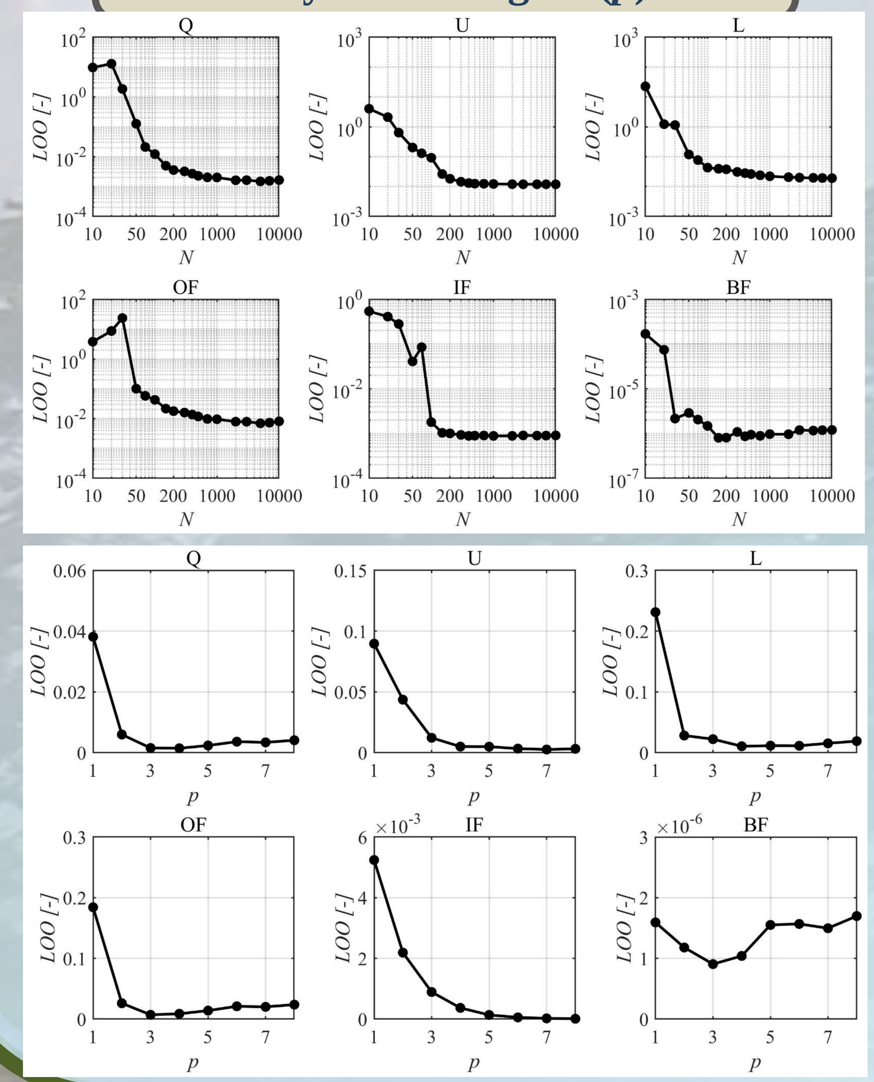
3. Data and Scenarios analysis

Schemes	Calibration		Forecast	
	Model	Calibration method	Model	State-parameter updating
1	NAM	GLUE	NAM	None
2			NAM	States updated
3			NAM	Dual parameters-states updated
4	PCE	GLUE	PCE	None
5			PCE	States updated
6			PCE	Dual parameters-states updated

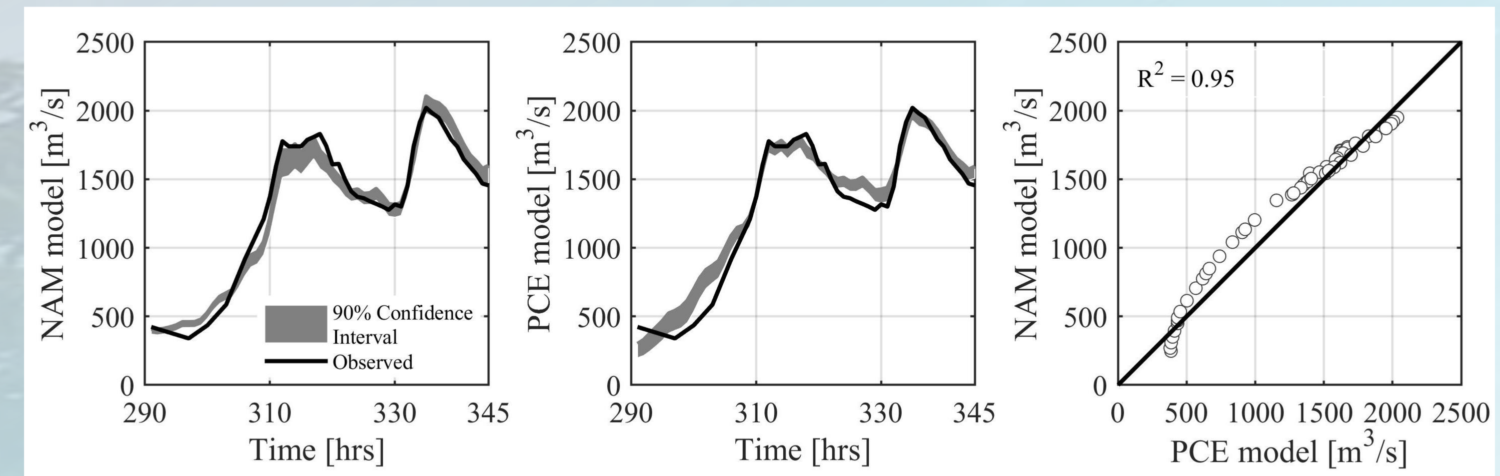


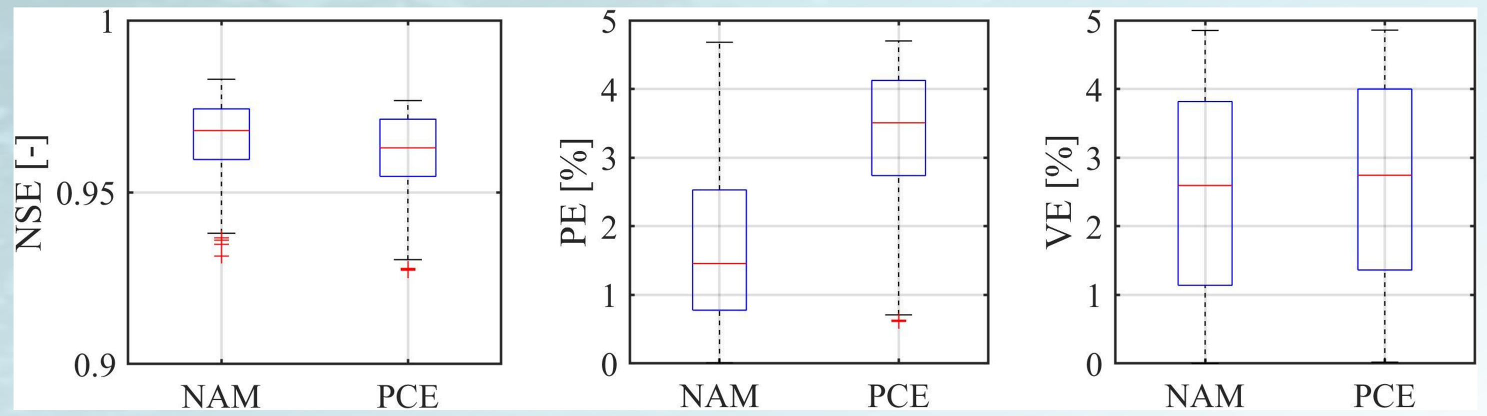
4. PCE model construction

Effects of Experiment Design (N) & Polynomial degree (p)

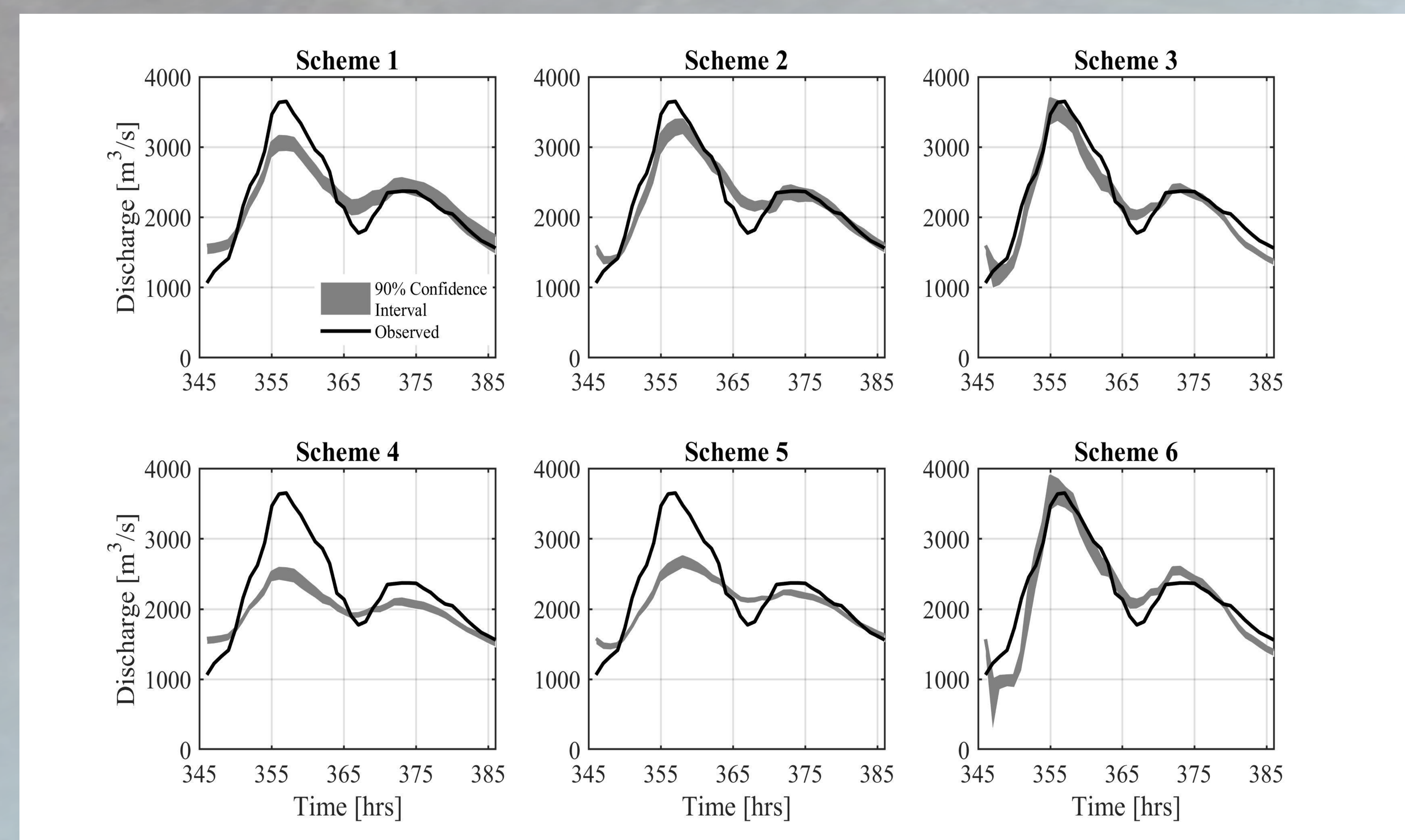


Comparisons of results of MIKE-NAM vs. Metamodel-PCE (Experiment design, N = 1000 and Polynomial Degree, p = 3)

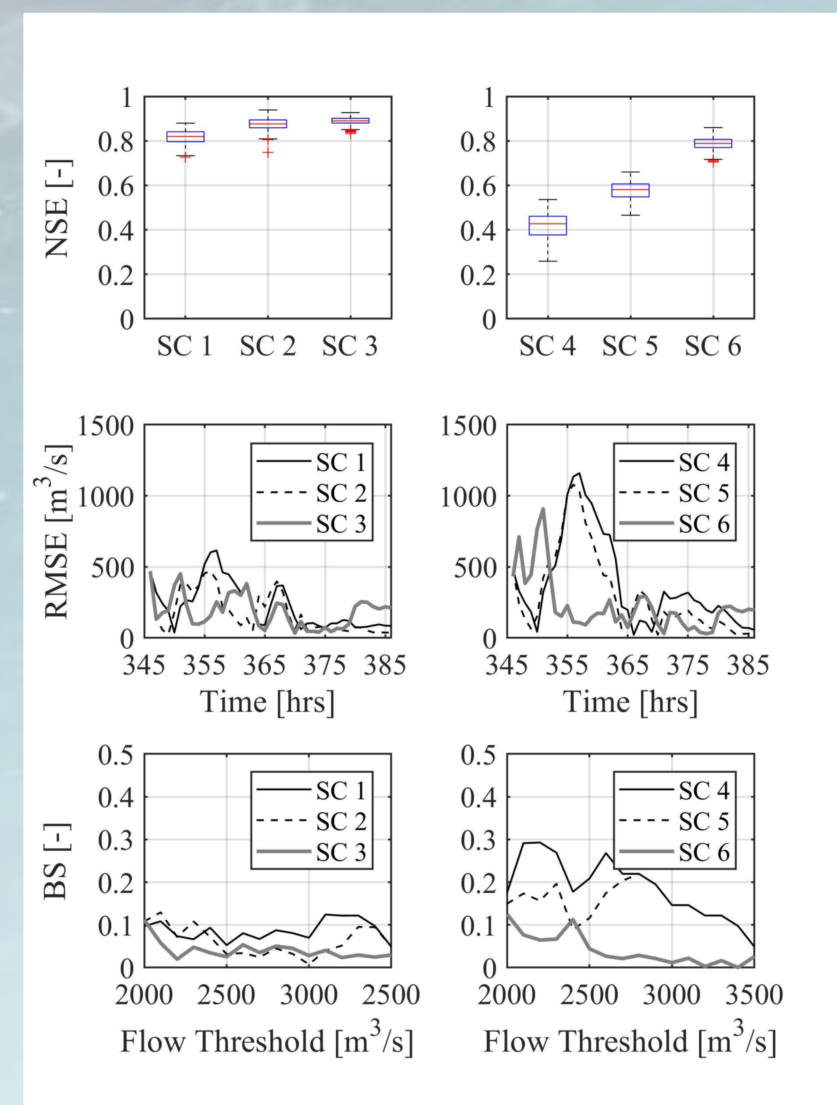




5. Real-time flood forecasting based on PCE and Dual EnKF



The result of model forecasting in real-time; Scheme 1 and 4 are NAM model and PCE model; Scheme 2 and 5 are NAM model and PCE mode with updated state using EnKF; Scheme 3 and 6 are NAM model and PCE model with dual parameter-state updated using Dual-EnKF



The verification of model forecasting, SC means Scheme

6. Conclusions

- ❑ PCE model is able to efficiently quantify uncertainties caused by many sources with ten time faster than NAM model
- ❑ The GLUE method can be used to generate the initial input for EnKF to imprive efficient of forecasting
- ❑ Results forecasted with a metamodel based on PCE method are as good as those by MIKE-NAM modelthrough automatic updating of states and parameters by EnKF