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Research on real-time correction of flood forecasts in the middle reaches of the Yellow River using AR、ARMAX and LSTM models

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Abstract

The development of flood forecasting technology is crucial to flood control. Therefore, it is very essential to use the method of real-time error correction to improve the accuracy and reliability of the flood forecasting model. For flood forecasting, this study evaluated the performance of a single Excess Infiltration and Excess Storage (EIES) flood forecast model and the forecast model after error correction using the linear Auto Regressive, Auto Regressive Moving Average with exogenous inputs (ARMAX), and Long Short-term Memory Network (LSTM), and then compared the performance of each model forced with historical flood data in the upper reaches of Jingle station of the Fen River in China. These EIES-standalone, EIES-AR, EIES-ARMAX, and EIES-LSTM frameworks are field-tested for 1- to 6-hours lead-time flood forecasting with historical flood data. The capability of the four models are compared using the mean absolute error (MAE), Nash–Sutcliffe efficiency (NSE), Pearson's correlation coefficients (r), and Percent error in volume (Evol). The evaluation measures analysis reveal that EIES-AR and EIES-ARMAX perform acceptable when the lead time is 1 hour(NSE>0.7), but poorly when the lead time is 2-6 hours; EIES-LSTM model performs well and is the best approach of these models for short to medium range flood forecasting with up to 6 hours lead-time(NSE[?]0.75).

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Event No.	Total rainfall(mm)	Rain duration(h)	Rising flow(mm)	Rainfall center of gravity
980622	25.20	35	2.44	宁化堡
980630	40.42	26	3.70	杜家村
980711	33.27	33	17.00	圪洞子
990710	28.37	24	1.20	东马坊
990719	7.48	8	3.00	堂儿
990817	20.07	20	1.47	静乐
000811	6.95	9.00	3.54	圪洞子
000827	15.49	16	9.70	杜家村
020626	49.23	15.00	21.40	宋家崖
030729	76.95	30	4.71	杜家村

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Variable	Description	Value
WM	Average catchment storage capacity	129.4
cke	Water area evaporation conversion	0.884
c	Deep evaporation coefficient	0.635
fc	Steady infiltration rate	8.366
k	Soil permeability coefficient	0.531
ckg	Extinction coefficient of underground runoff	0.995
EX	Index of free water storage capacity curve	1.884
SM	Free water storage capacity	23.541
CKI	Extinction coefficient of flow in soil	0.998
CI	Outflow coefficient of soil	0.347
CG	Underground runoff coefficient	0.361

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Lead-Time	period	Qualified rate α(%)		
		Flood peak	Flood peak occurrence time	Mean value
1h	training	78.3	85.4	81.85
	test	80.1	88.6	84.35
2h	training	70.0	81.3	76.1
	test	74.6	84.9	79.75
3h	training	65.4	78.7	72.05
	test	67.2	79.6	73.4
4h	training	62.5	74.2	68.35
	test	64.6	76.3	70.45
5h	training	56.7	75.1	65.9
	test	60.3	75.2	67.75
6h	training	55.7	63.9	59.8
	test	58.0	66.5	62.25

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Lead-Time	period	Qualified rate α(%)		
		Flood peak	Flood peak occurrence time	Mean value
1h	training	75.2	85.1	80.15
	test	78.6	85.4	81
2h	training	66.8	80.2	73.5
	test	70.2	81.6	75.9
3h	training	61.5	74.3	67.9
	test	61.9	74.5	68.2
4h	training	58.3	72.2	65.25
	test	55.7	73.1	64.4
5h	training	54.4	72.5	63.45
	test	53.1	70.2	61.65
6h	training	51.5	65.7	58.6
	test	50.20	67.4	58.8

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Lead-Time	period	Qualified rate α(%)		
		Flood peak	Occurrence time of flood peak	Mean value
1h	training	92.4	96.3	94.35
	test	94.5	98.2	96.35
2h	training	90.6	93.5	92.05
	test	92.7	94.1	93.4
3h	training	87.2	94.7	90.95
	test	88.6	92.6	90.6
4h	training	85.4	90.1	87.75
	test	87.3	91.5	89.4
5h	training	80.1	87.4	83.75
	test	82.5	88.3	85.4
6h	training	77.3	85.9	81.6
	test	80.8	86.7	82.75

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Model	Correlation Coefficient (r)			Nash Sutcliffe Efficiency (E)			Error of Peak Discharge (EQ_{peak})(%)			Error of Time to Peak (ET_{peak})		
	1h	3h	6h	1h	3h	6h	1h	3h	6h	1h	3h	6h
EIES-standalone	0.922	0.895	0.870	0.782	0.721	0.547	-48.3	-61.4	-75.6	2	0	1
EIES-AR	0.958	0.944	0.921	0.826	0.771	0.665	-36.9	-41.5	-58.6	0	0	0
EIES-ARMAX	0.913	0.904	0.882	0.796	0.714	0.619	-46.8	-52.3	-70.6	1	1	0
EIES-LSTM	0.992	0.981	0.976	0.991	0.885	0.822	-8.2	-14.8	-18.3	0	0	0

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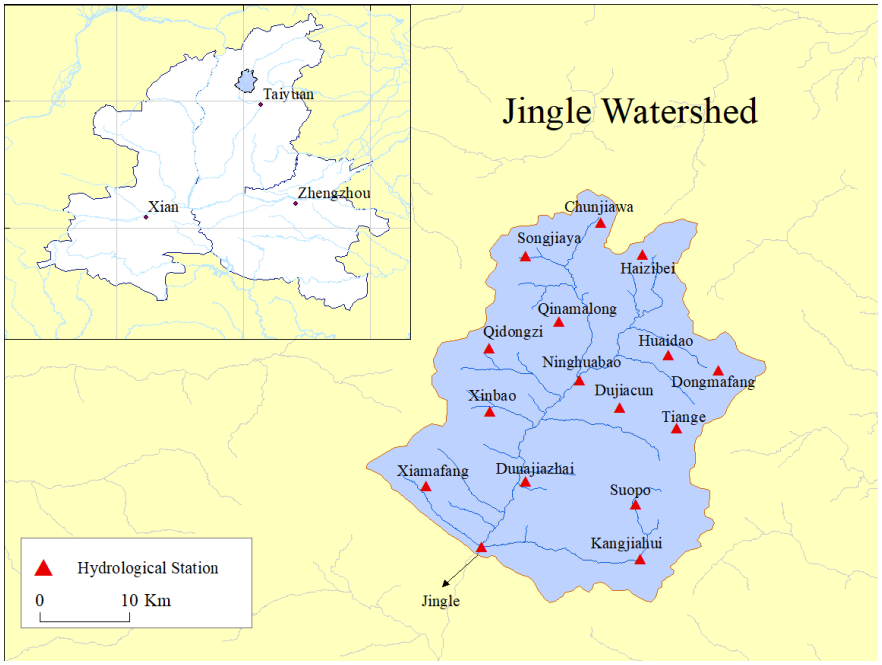

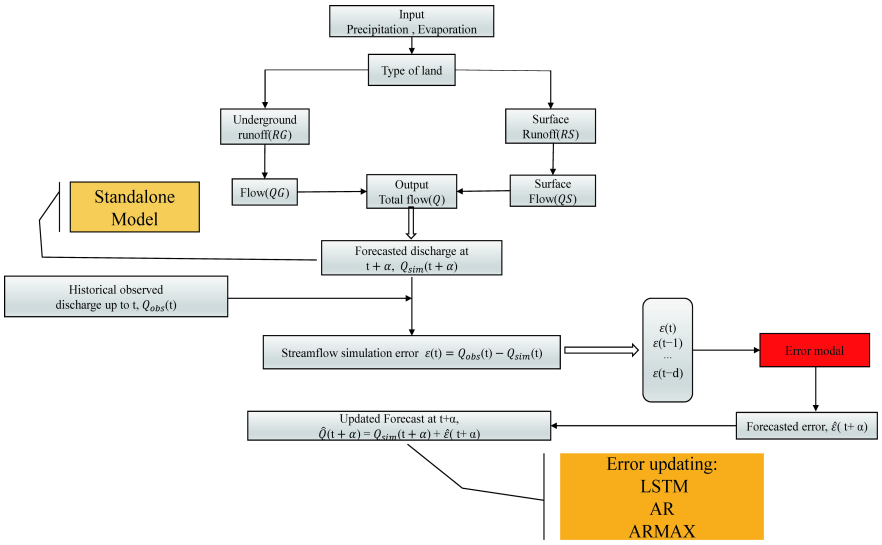

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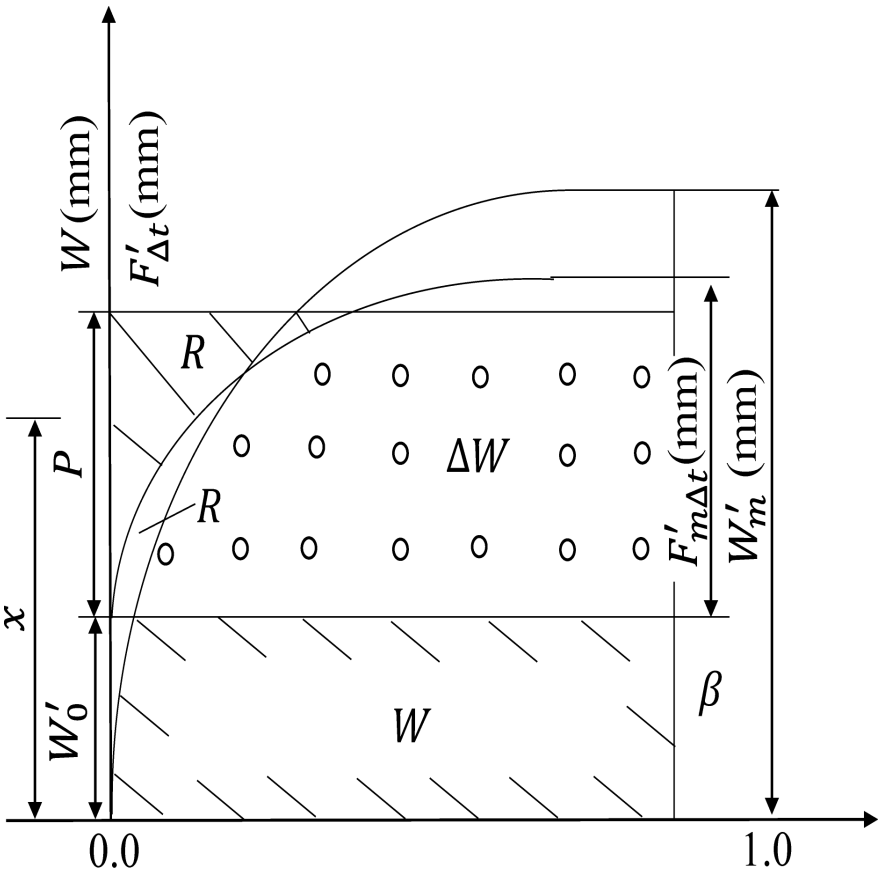

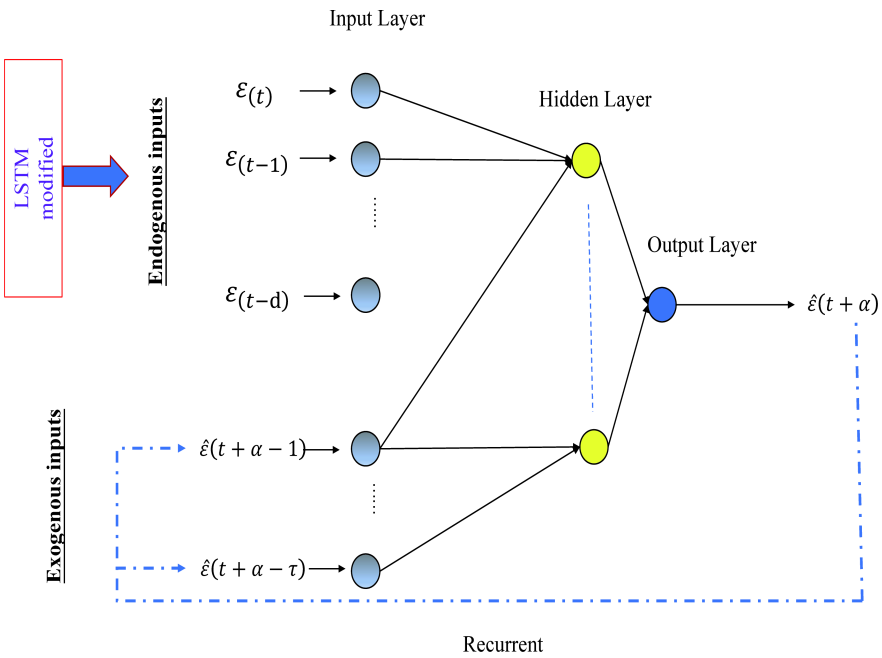

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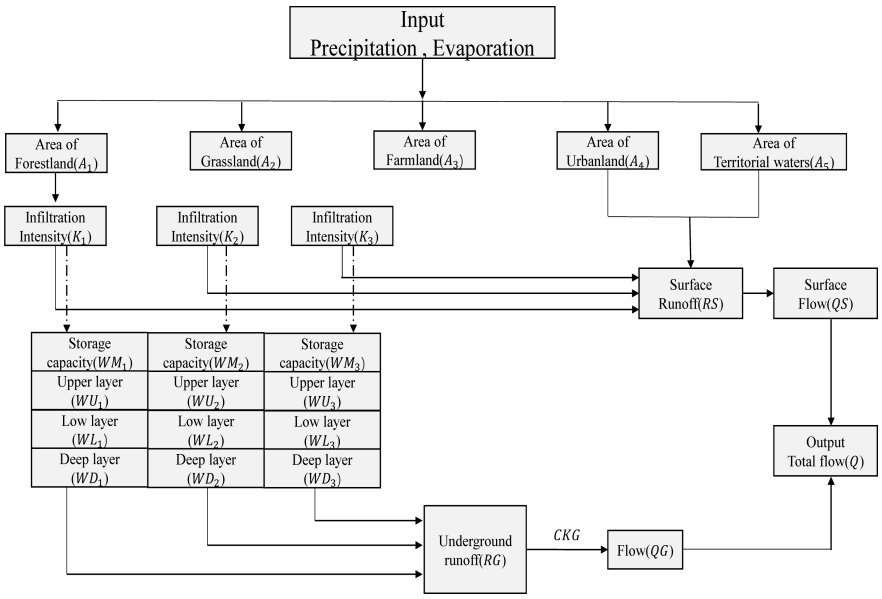

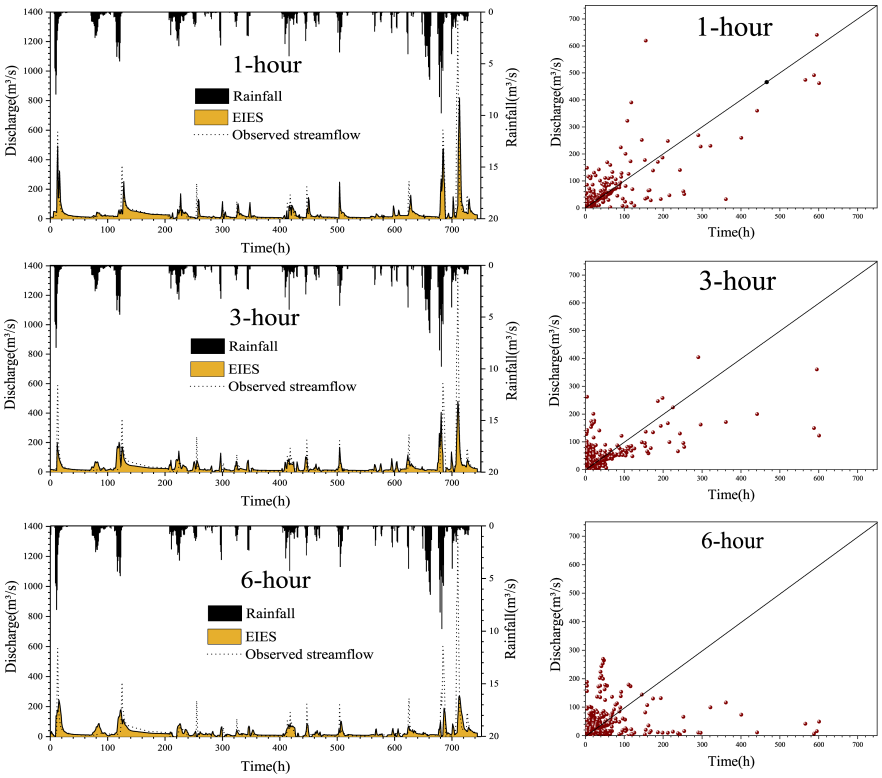

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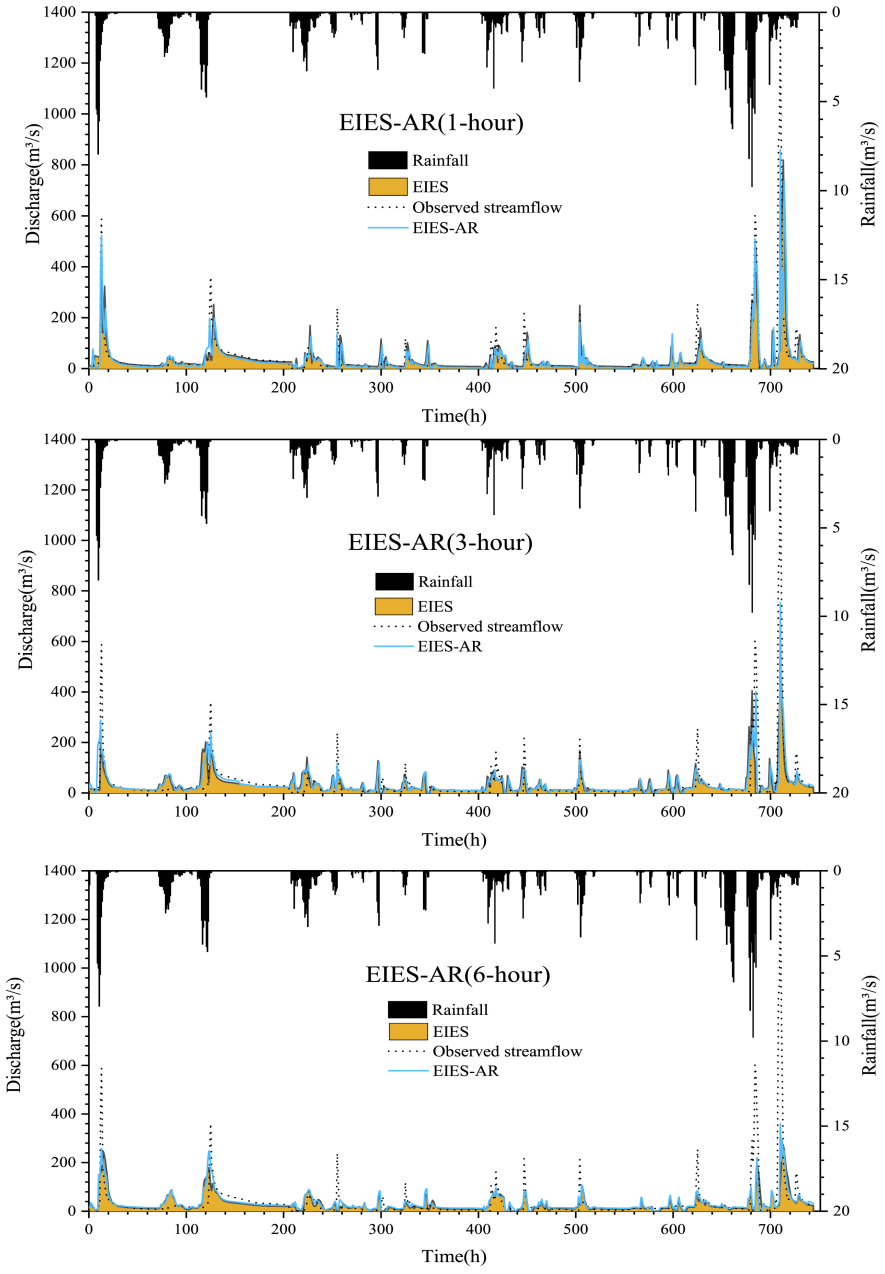

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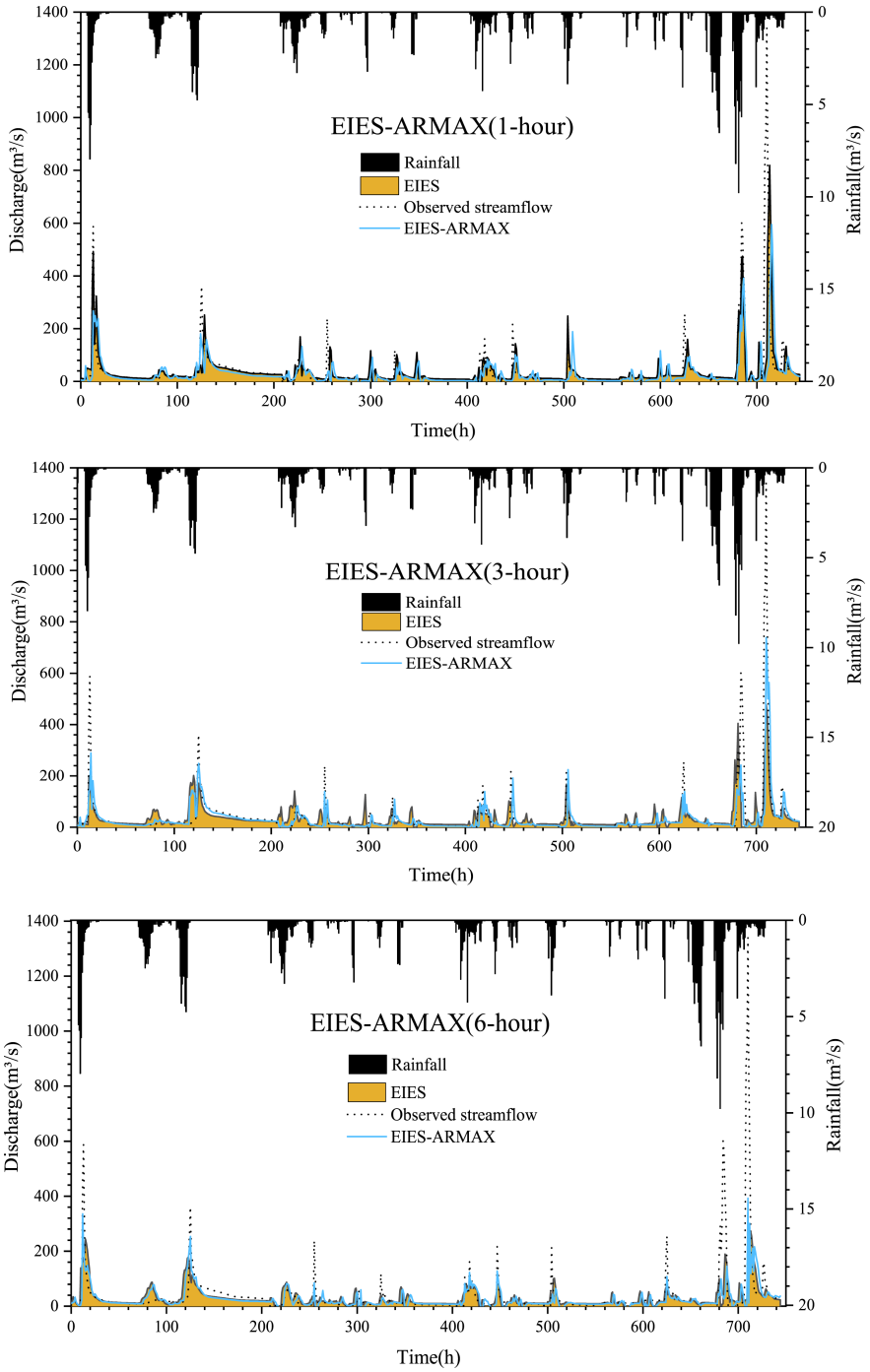

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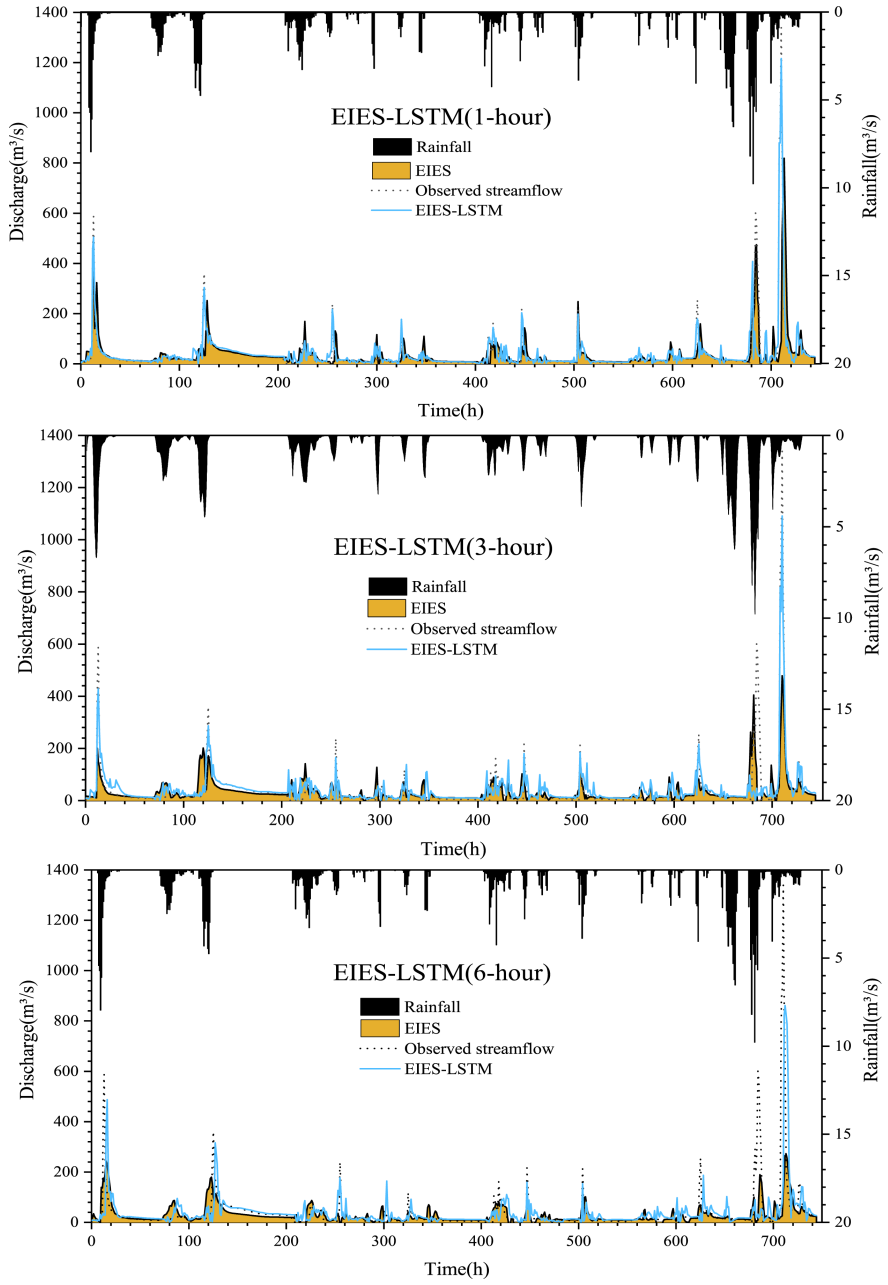

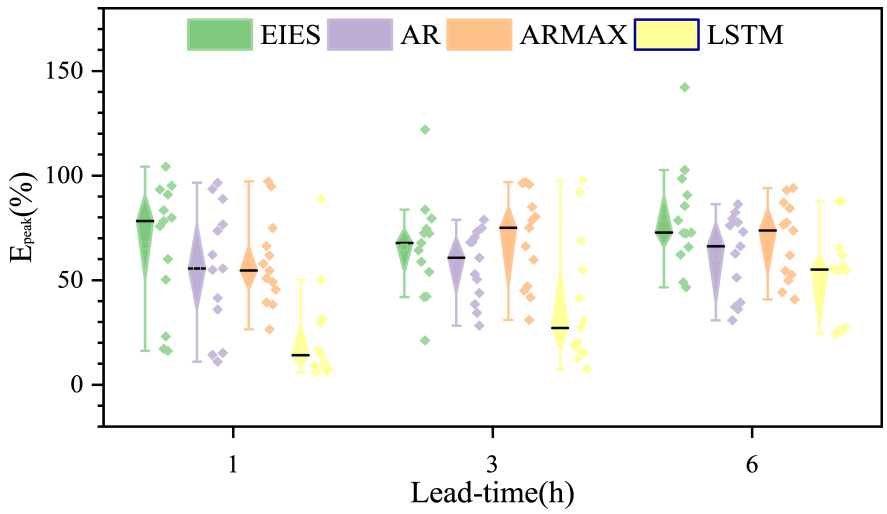

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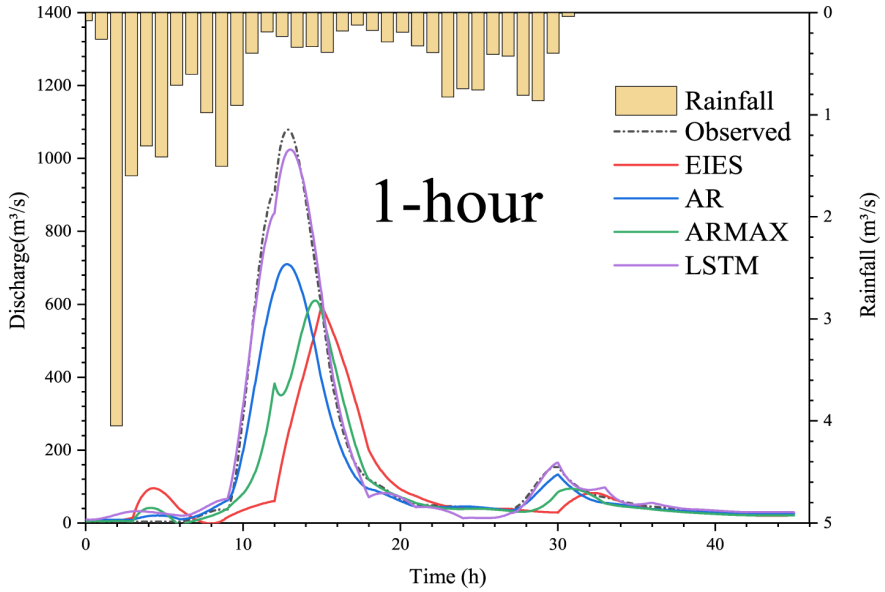

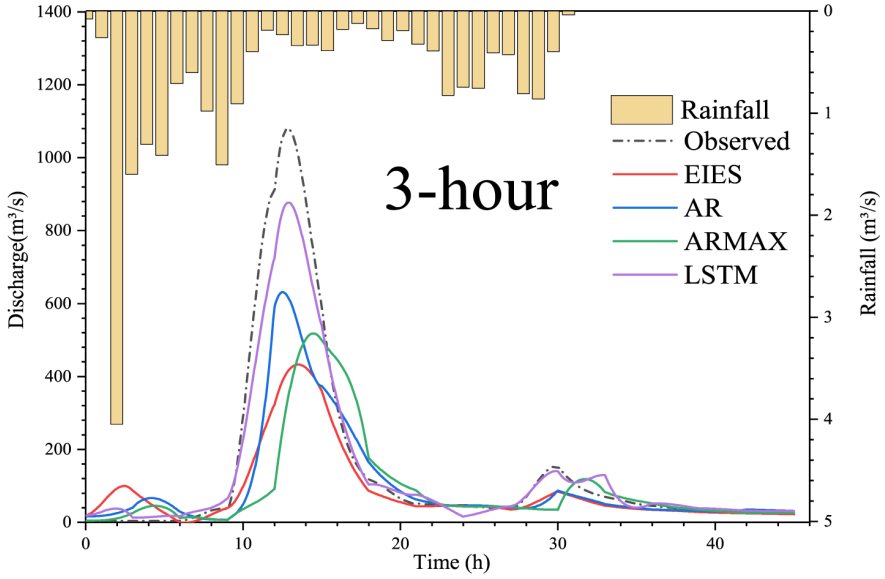

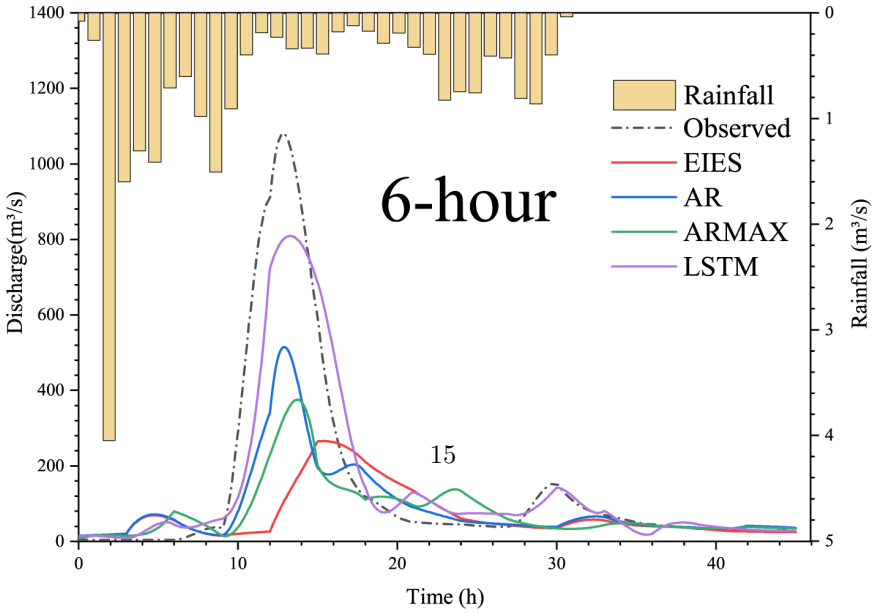
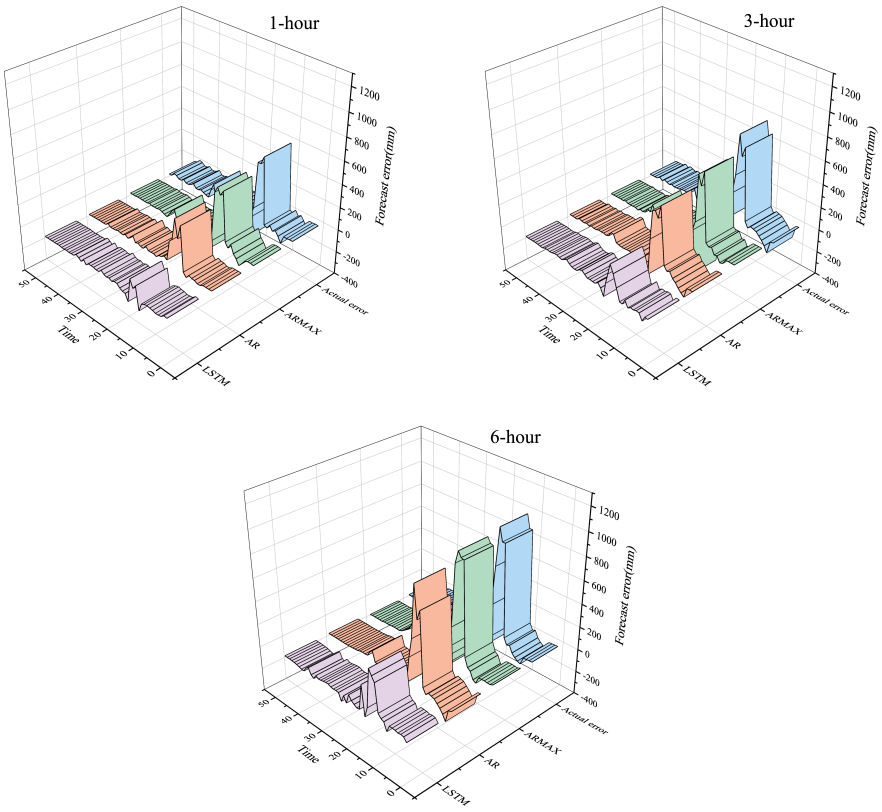
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