

## Supplementary Materials:

# Future Changes of Precipitation over the Han River Basin Using NEX-GDDP dataset and the SVR\_QM Method

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**Abstract:** After the release of the high-resolution downscaled National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset, it is worth exploiting this dataset to improve the simulation and projection of local precipitation. This study developed support vector regression (SVR) and quantile mapping (SVR\_QM) ensemble and correction models on the basis of historic precipitation in the Han River basin and the 21 NEX-GDDP models. The generated SVR\_QM models were applied to project changes of precipitation during the 21st century for the region. Several statistical metrics, including Pearson's correlation coefficient (PCC), root mean squared error (RMSE), and relative bias (Rbias), were used for evaluation and comparative analyses. The results demonstrated the superior performance of SVR\_QM compared with multi-layer perceptron (MLP), SVR, and random forest (RF), as well as simple model average (MME) ensemble methods and single NEX-GDDP models. PCC was up to 0.84 from 0.61–0.71 for the single NEX-GDDP models, RMSE was up to 34.02 mm from 48–51 mm, and Rbias values were almost removed. Additionally, the projected precipitation changes during the 21st century in most stations had an increasing trend under both Representative Concentration Pathway RCP4.5 and RCP8.5 emissions scenarios; the regional average precipitation during the middle (2040–2059) and late (2070–2089) 21st century increased by 3.54% and 5.12% under RCP4.5 and by 7.44% and 9.52% under RCP8.5, respectively.

**Keywords:** machine learning; quantile mapping; NEX-GDDP; precipitation; Han River basin

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The supplementary materials mainly include the evaluation of 21 NEX-GDDP models and MME for specific stations in this region. Each section/table/figure has been refereed and cited in the manuscript.

**Table 1.** the evaluation of 21 NEX-GDDP models and MME for specific stations in this region.

Mode\station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	1	20	21	
1	RMS	99.27	84.74	98.44	74.84	81.13	66.89	59.81	75.24	72.76	67.27	68.02	77.03	77.91	86.49	72.20	66.47	65.92	63.35	68.52	60.05	55.31
	PCC	0.35	0.36	0.33	0.44	0.44	0.51	0.60	0.45	0.37	0.53	0.41	0.47	0.48	0.34	0.48	0.46	0.59	0.45	0.54	0.45	0.57
	Rbias	12.22	13.95	14.45	17.75	13.68	7.66	17.12	6.82	8.43	19.77	3.34	-4.10	-9.93	0.32	-12.78	-3.05	-14.21	-6.09	-20.65	6.01	-17.78
2	RMS	88.75	68.44	84.14	62.32	69.38	62.29	51.42	63.73	66.42	60.40	58.65	64.50	65.20	78.38	67.19	52.48	54.13	56.85	56.20	50.33	44.92
	PCC	0.41	0.52	0.45	0.56	0.54	0.53	0.67	0.58	0.40	0.53	0.53	0.58	0.59	0.46	0.54	0.63	0.70	0.53	0.69	0.59	0.70
	Rbias	11.09	9.17	10.54	12.59	8.99	3.00	14.04	2.64	4.51	15.71	5.27	-3.79	-10.52	4.41	-9.11	-1.08	-13.10	-0.58	-18.45	10.04	-12.35
3	RMS	89.24	72.80	85.31	71.80	77.02	70.25	60.13	71.52	69.45	69.90	60.85	68.80	72.37	73.69	59.41	57.27	58.38	53.43	60.19	53.64	46.32
	PCC	0.46	0.53	0.48	0.50	0.49	0.49	0.62	0.53	0.44	0.48	0.53	0.55	0.51	0.54	0.65	0.59	0.65	0.60	0.64	0.55	0.68
	Rbias	16.03	15.62	16.89	19.67	15.60	10.34	21.76	9.88	11.41	23.84	9.49	-1.01	-8.28	7.43	-6.56	2.89	-11.61	1.87	-17.45	14.09	-13.90
4	RMS	92.53	72.44	90.51	67.78	76.00	63.37	47.19	67.38	63.51	53.60	52.44	62.08	62.28	75.65	66.06	48.78	54.93	51.67	57.36	42.22	43.75
	PCC	0.32	0.40	0.31	0.39	0.38	0.46	0.67	0.48	0.38	0.58	0.58	0.61	0.64	0.46	0.55	0.66	0.70	0.57	0.68	0.67	0.73
	Rbias	1.78	1.49	2.71	2.44	-1.78	-8.85	2.09	-9.63	-7.01	5.02	-6.62	-13.51	-18.10	-10.73	-20.69	-10.76	-20.97	-12.85	-24.00	-1.01	-19.94
5	RMS	111.42	100.24	109.22	87.64	91.45	81.20	63.02	79.77	77.05	68.24	66.93	69.78	69.54	90.91	67.87	62.90	59.38	63.45	66.91	60.90	55.56
	PCC	0.25	0.25	0.25	0.38	0.38	0.41	0.61	0.49	0.40	0.59	0.54	0.60	0.60	0.40	0.60	0.61	0.69	0.58	0.60	0.60	0.64
	Rbias	8.30	10.62	10.00	15.47	11.00	11.66	21.48	11.28	13.42	29.69	14.77	7.85	1.84	15.95	0.40	10.42	-1.35	9.30	-8.22	23.18	-0.22
6	RMS	104.69	88.87	102.92	86.17	93.33	76.97	63.05	81.19	81.37	71.03	67.17	70.66	75.15	91.53	69.04	66.80	64.33	62.97	68.18	61.78	60.07
	PCC	0.33	0.39	0.33	0.37	0.32	0.43	0.60	0.42	0.28	0.47	0.47	0.55	0.51	0.32	0.55	0.50	0.62	0.51	0.57	0.52	0.55
	Rbias	10.02	10.41	10.77	15.69	11.18	7.27	18.94	6.20	8.41	18.81	6.22	-2.86	-6.77	3.43	-8.40	0.32	-10.60	-1.04	-13.81	12.65	-8.49
7	RMS	97.45	78.97	89.72	73.07	78.04	69.64	53.29	73.64	72.91	62.71	60.28	67.01	72.72	79.71	73.88	58.52	64.47	60.77	67.80	56.16	58.76
	PCC	0.30	0.38	0.38	0.43	0.44	0.47	0.68	0.48	0.35	0.56	0.55	0.59	0.52	0.46	0.46	0.59	0.60	0.52	0.54	0.54	0.51
	Rbias	7.08	9.06	8.89	13.97	8.77	5.63	16.65	5.00	6.42	19.79	4.83	-3.29	-8.63	1.48	-10.94	-1.39	-12.13	-1.98	-19.16	9.24	-15.40
8	RMS	108.88	92.81	102.17	83.42	92.96	77.64	64.46	78.85	76.13	70.43	66.03	73.82	81.70	91.71	67.69	59.56	62.14	62.75	63.10	59.17	53.29

	PCC	0.26	0.31	0.32	0.42	0.38	0.50	0.63	0.53	0.45	0.54	0.56	0.51	0.42	0.39	0.60	0.61	0.64	0.58	0.62	0.58	0.63
	Rbias	14.03	15.63	16.37	20.69	18.49	14.83	22.96	14.42	15.43	25.49	11.94	0.07	-6.69	14.05	-1.38	4.00	-9.31	4.84	-15.02	17.08	-9.43
	RMS	96.35	83.27	98.83	81.10	84.18	68.89	64.63	77.96	68.40	56.03	59.87	61.54	66.35	77.00	66.59	50.06	59.60	55.50	55.56	54.36	46.41
9	PCC	0.35	0.37	0.29	0.33	0.35	0.46	0.54	0.39	0.43	0.70	0.56	0.65	0.60	0.49	0.57	0.70	0.65	0.59	0.70	0.58	0.70
	Rbias	13.72	17.59	15.71	20.49	12.51	9.97	23.23	9.29	11.53	28.38	11.06	1.89	-4.18	7.35	-6.25	5.31	-8.23	2.06	-13.31	17.01	-7.35
	RMS	95.74	80.57	93.30	67.54	78.20	66.70	59.85	70.10	69.65	65.13	56.65	67.50	65.97	79.45	67.23	60.04	57.99	56.96	60.09	53.42	47.68
10	PCC	0.40	0.44	0.40	0.54	0.47	0.50	0.59	0.51	0.40	0.53	0.59	0.56	0.59	0.45	0.55	0.56	0.67	0.56	0.64	0.59	0.67
	Rbias	14.86	16.18	15.44	18.91	12.76	8.91	19.15	8.75	9.10	21.66	7.06	-3.33	-9.09	7.01	-9.21	0.66	-12.52	-1.31	-18.87	12.36	-12.69
	RMS	97.91	82.32	97.89	83.11	87.67	82.84	66.17	86.24	80.75	69.01	68.85	76.24	75.67	98.88	76.33	66.23	64.62	67.30	62.51	62.43	46.58
11	PCC	0.30	0.34	0.27	0.30	0.32	0.30	0.52	0.33	0.26	0.48	0.44	0.46	0.48	0.23	0.45	0.48	0.59	0.43	0.62	0.46	0.70
	Rbias	8.32	11.26	10.46	17.79	12.49	10.58	21.40	10.71	10.96	24.69	10.03	0.25	-3.55	10.15	-7.26	2.24	-8.50	1.49	-13.32	14.02	-8.68
	RMS	92.62	78.09	90.86	71.45	74.43	77.08	64.78	85.58	80.06	71.48	70.83	76.93	80.49	88.34	80.99	69.41	70.59	66.19	76.73	63.51	62.06
12	PCC	0.45	0.50	0.45	0.54	0.55	0.40	0.55	0.34	0.30	0.46	0.41	0.46	0.42	0.35	0.38	0.44	0.52	0.46	0.41	0.47	0.47
	Rbias	8.45	11.46	10.75	13.01	10.27	1.73	10.58	1.83	3.26	14.47	2.01	-7.87	-13.55	-0.43	-12.93	-4.15	-16.56	-4.84	-23.46	7.33	-16.53
	RMS	96.26	78.97	91.98	69.36	75.93	66.21	55.18	72.04	65.37	60.53	58.36	63.92	69.80	81.04	62.73	52.98	58.43	56.21	59.77	53.52	48.94
13	PCC	0.30	0.35	0.33	0.43	0.43	0.46	0.62	0.45	0.43	0.56	0.56	0.61	0.54	0.41	0.61	0.65	0.66	0.56	0.64	0.57	0.66
	Rbias	6.98	6.23	7.33	8.09	3.44	1.50	15.46	0.73	4.95	19.65	7.52	-1.69	-5.87	0.14	-9.20	1.06	-10.13	0.65	-13.72	12.40	-8.70
	RMS	98.07	83.97	101.33	72.01	81.56	77.69	59.89	77.79	72.14	62.10	56.45	61.47	65.64	82.17	70.14	57.07	60.28	57.43	64.18	52.90	54.94
14	PCC	0.35	0.36	0.28	0.45	0.41	0.32	0.56	0.40	0.35	0.56	0.60	0.64	0.60	0.41	0.51	0.61	0.64	0.56	0.58	0.60	0.57
	Rbias	7.91	7.21	8.56	11.18	7.32	4.32	15.44	3.51	6.78	19.36	5.10	-4.07	-9.57	1.72	-9.37	-1.50	-13.46	-1.30	-17.62	9.44	-12.90
	RMS	106.46	80.93	97.05	71.84	81.85	73.50	57.53	75.45	65.30	57.99	53.28	66.19	71.02	83.64	62.60	51.30	63.22	52.28	63.86	48.57	52.14
15	PCC	0.24	0.42	0.34	0.48	0.41	0.41	0.58	0.46	0.45	0.55	0.61	0.56	0.53	0.40	0.61	0.64	0.60	0.61	0.59	0.61	0.61
	Rbias	7.92	8.93	9.26	10.88	4.98	1.70	13.72	1.00	3.17	15.20	2.93	-6.86	-11.72	-0.86	-13.84	-3.81	-15.12	-4.22	-18.91	7.04	-15.13
	RMS	93.01	74.73	90.79	67.77	76.72	67.12	55.56	72.74	64.44	63.06	59.57	72.49	75.76	85.28	69.82	58.46	62.77	58.55	64.74	54.84	47.24
16	PCC	0.35	0.42	0.35	0.44	0.39	0.40	0.56	0.40	0.39	0.49	0.48	0.49	0.47	0.30	0.49	0.54	0.60	0.47	0.58	0.48	0.68

	Rbias	8.24	6.86	8.51	8.68	4.48	-1.94	8.81	-2.62	0.10	12.85	-1.35	-6.48	-10.97	-4.04	-15.65	-5.59	-14.80	-8.08	-18.95	3.83	-14.10
	RMS	97.49	79.03	89.65	69.85	78.68	76.38	66.73	78.87	71.75	62.36	62.75	73.50	70.02	88.83	73.55	56.99	61.04	60.58	55.77	54.01	42.40
17	PCC	0.31	0.40	0.40	0.49	0.43	0.35	0.48	0.39	0.37	0.55	0.47	0.47	0.54	0.30	0.45	0.58	0.62	0.47	0.70	0.52	0.74
	Rbias	8.89	8.70	9.80	12.86	8.01	3.39	14.53	2.75	4.54	16.03	1.89	-5.58	-10.74	-0.21	-13.30	-4.15	-14.63	-5.21	-18.56	5.12	-15.41
	RMS	100.60	85.54	101.27	73.60	84.18	71.89	57.30	73.14	70.62	58.79	58.26	59.88	63.55	82.04	67.23	50.70	53.90	53.31	56.71	46.96	47.44
18	PCC	0.28	0.32	0.26	0.41	0.35	0.38	0.57	0.45	0.34	0.53	0.51	0.64	0.62	0.40	0.54	0.65	0.71	0.57	0.68	0.63	0.67
	Rbias	8.81	11.25	11.62	13.54	10.26	4.22	11.81	3.58	4.69	11.89	-0.18	-9.61	-15.01	0.65	-11.71	-5.97	-17.62	-6.21	-21.13	5.51	-17.00
	RMS	83.94	67.81	83.06	59.11	68.29	62.17	49.97	64.56	63.11	59.05	57.90	70.35	74.42	79.43	72.60	60.40	66.61	57.23	63.31	56.19	53.05
19	PCC	0.46	0.53	0.45	0.58	0.53	0.49	0.65	0.54	0.41	0.58	0.52	0.52	0.49	0.41	0.45	0.53	0.55	0.51	0.60	0.49	0.59
	Rbias	5.40	7.40	6.57	10.04	5.78	-0.41	7.79	-1.09	-0.43	13.97	-2.01	-5.79	-10.66	-5.24	-17.03	-4.96	-13.87	-8.68	-20.17	5.08	-16.11
	RMS	95.24	80.70	90.77	74.12	82.16	58.82	45.45	66.05	58.64	53.89	49.83	65.84	72.49	78.37	63.32	55.56	62.95	51.61	66.23	48.54	53.82
20	PCC	0.42	0.43	0.44	0.41	0.39	0.55	0.68	0.52	0.47	0.57	0.62	0.56	0.49	0.44	0.60	0.57	0.59	0.58	0.55	0.58	0.57
	Rbias	7.95	6.85	8.48	4.79	2.03	-6.28	4.57	-6.14	-5.32	7.33	-5.30	-15.22	-18.74	-6.94	-19.02	-11.18	-22.04	-11.58	-26.18	0.49	-21.79
	RMS	97.51	79.55	95.99	75.58	81.52	69.22	58.96	76.80	67.98	62.48	63.40	70.75	71.36	84.21	70.46	57.61	64.80	59.59	63.12	51.52	52.12
21	PCC	0.31	0.37	0.30	0.36	0.36	0.41	0.54	0.38	0.37	0.48	0.42	0.49	0.51	0.33	0.48	0.54	0.57	0.46	0.60	0.54	0.60
	Rbias	11.71	9.48	11.61	9.83	6.75	1.46	11.24	0.89	3.43	11.21	-1.45	-12.54	-17.98	-2.70	-13.83	-9.04	-21.96	-7.92	-25.35	1.31	-21.50
	RMS	85.59	70.45	77.18	61.17	65.25	54.06	44.12	60.73	57.65	49.32	49.76	57.66	56.01	65.44	54.08	47.49	55.25	53.41	55.83	43.41	44.16
MME	PCC	0.53	0.53	0.53	0.58	0.56	0.57	0.70	0.58	0.51	0.67	0.63	0.66	0.65	0.57	0.67	0.67	0.71	0.64	0.69	0.65	0.72
	Rbias	-0.11	4.89	5.81	8.80	8.30	9.18	13.89	8.39	6.58	12.84	4.06	-5.90	-6.05	0.13	-10.18	1.71	-12.98	-7.70	-15.87	11.45	-10.11