A nonlinear hybrid model to assess the impacts of climate variability and human activities on runoff at different time scales

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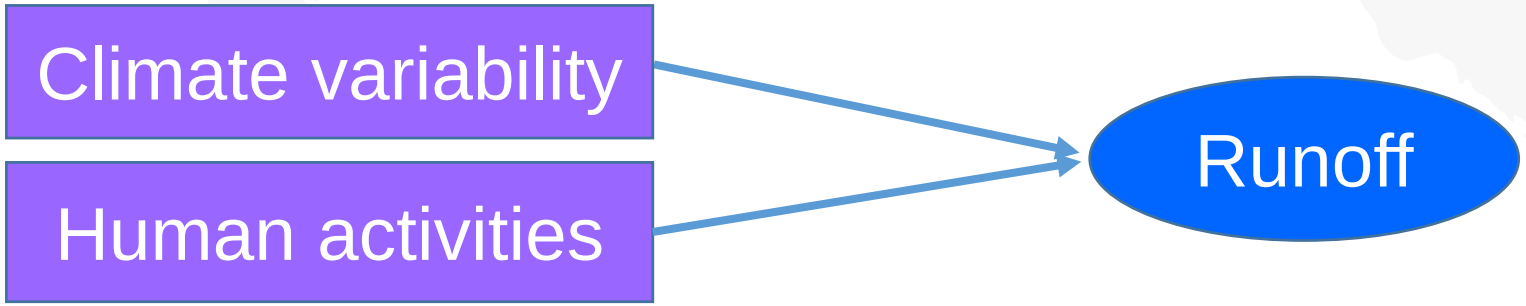
Outline

1 Background and Motivation

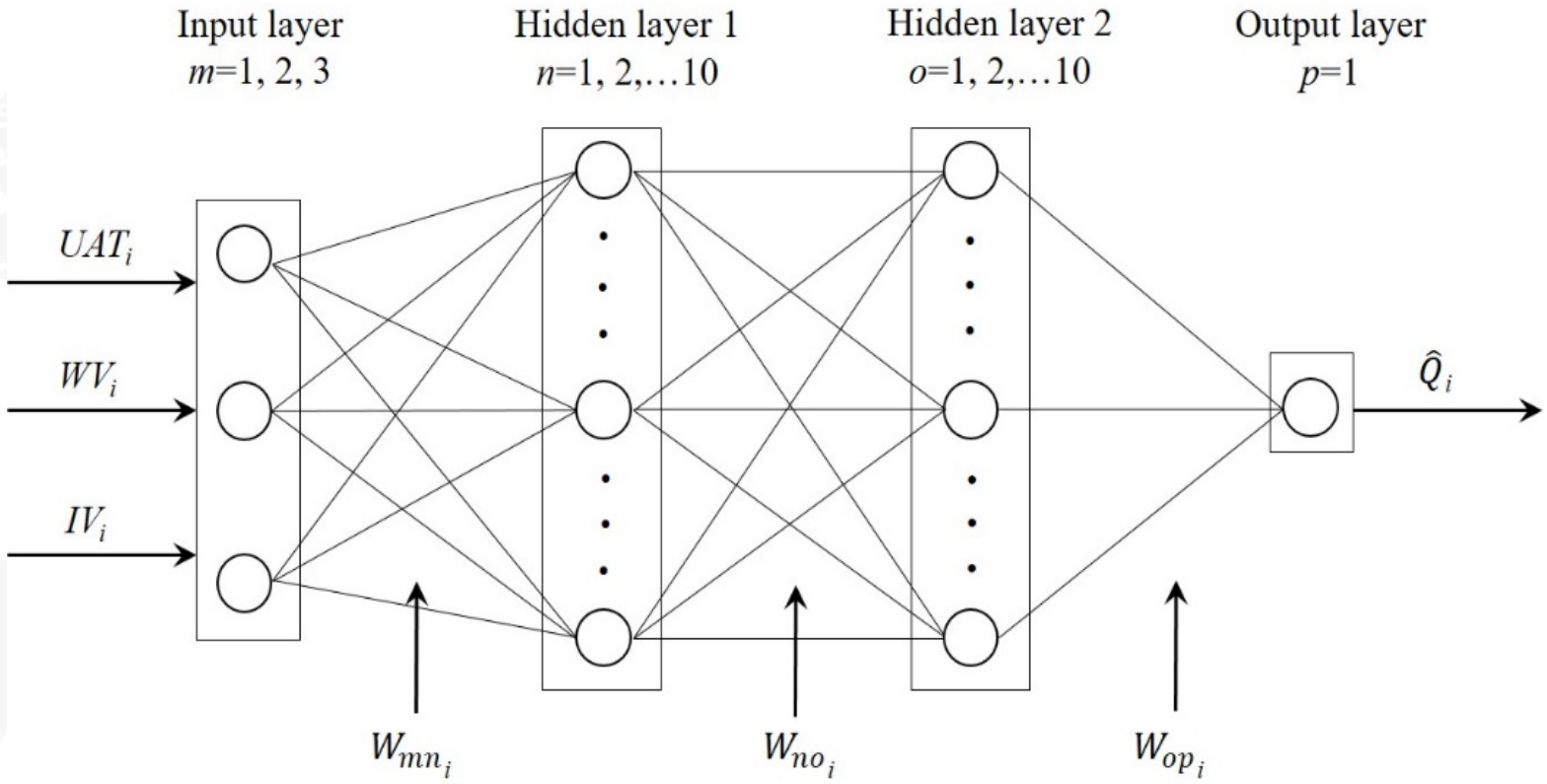
- The hydrological cycle has been remarkably influenced by climate variability and human activities (Hanasaki et al. 2018; Huntington 2006; Mittal et al. 2016).
- The impacts of climate variability and human activities on runoff at inter-annual and inter-decadal scales have rarely been assessed quantitatively.
- **Motivation**: To quantitatively evaluate the impacts of climate variability and human activities on runoff at different time scales.



2 Model Construction

ESMD (Extreme-point symmetric mode decomposition)

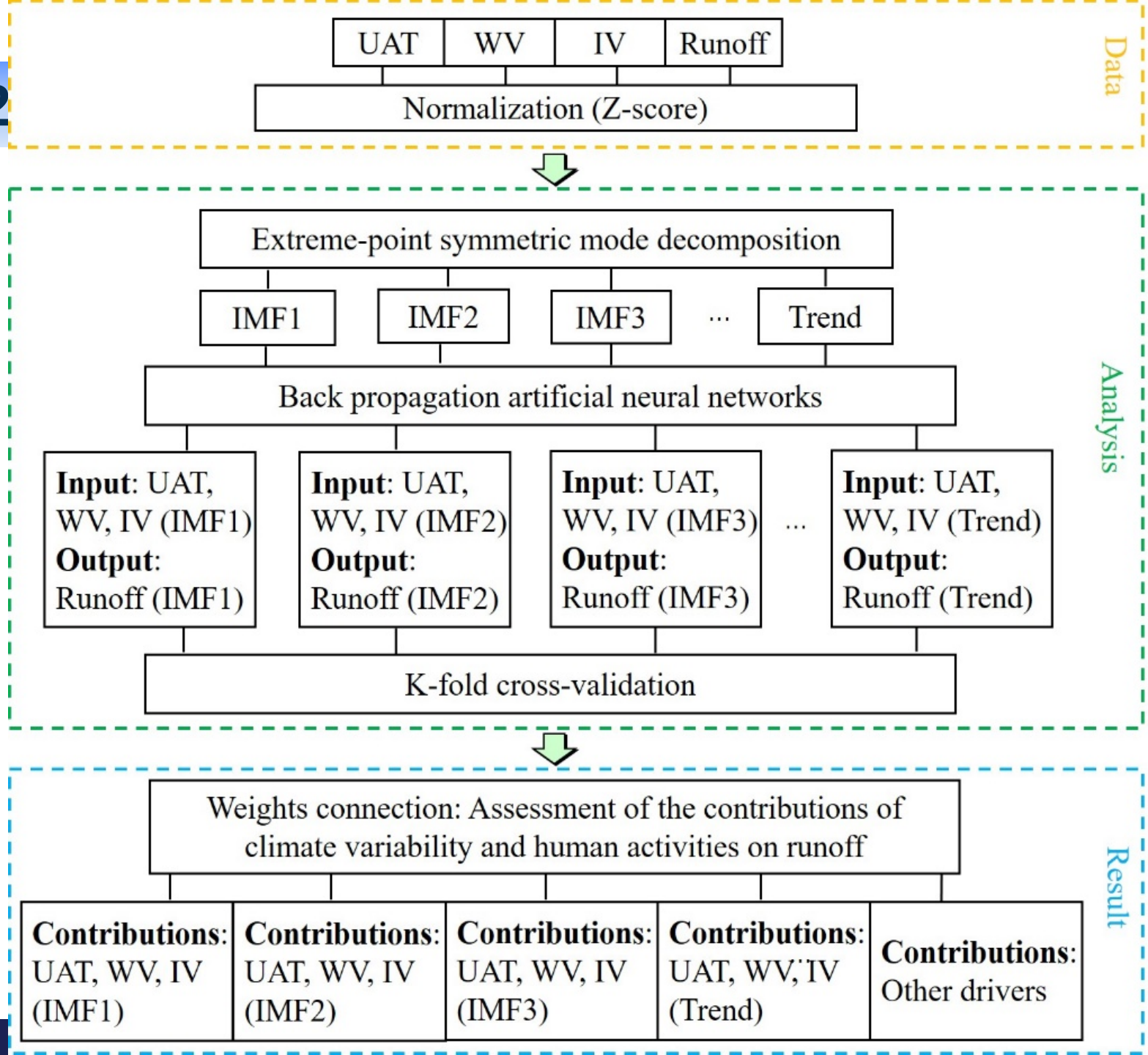
BPANN (Back-propagation artificial neural network)



Weights connection

Contributions

- **Unknown drivers**
- **Known drivers**



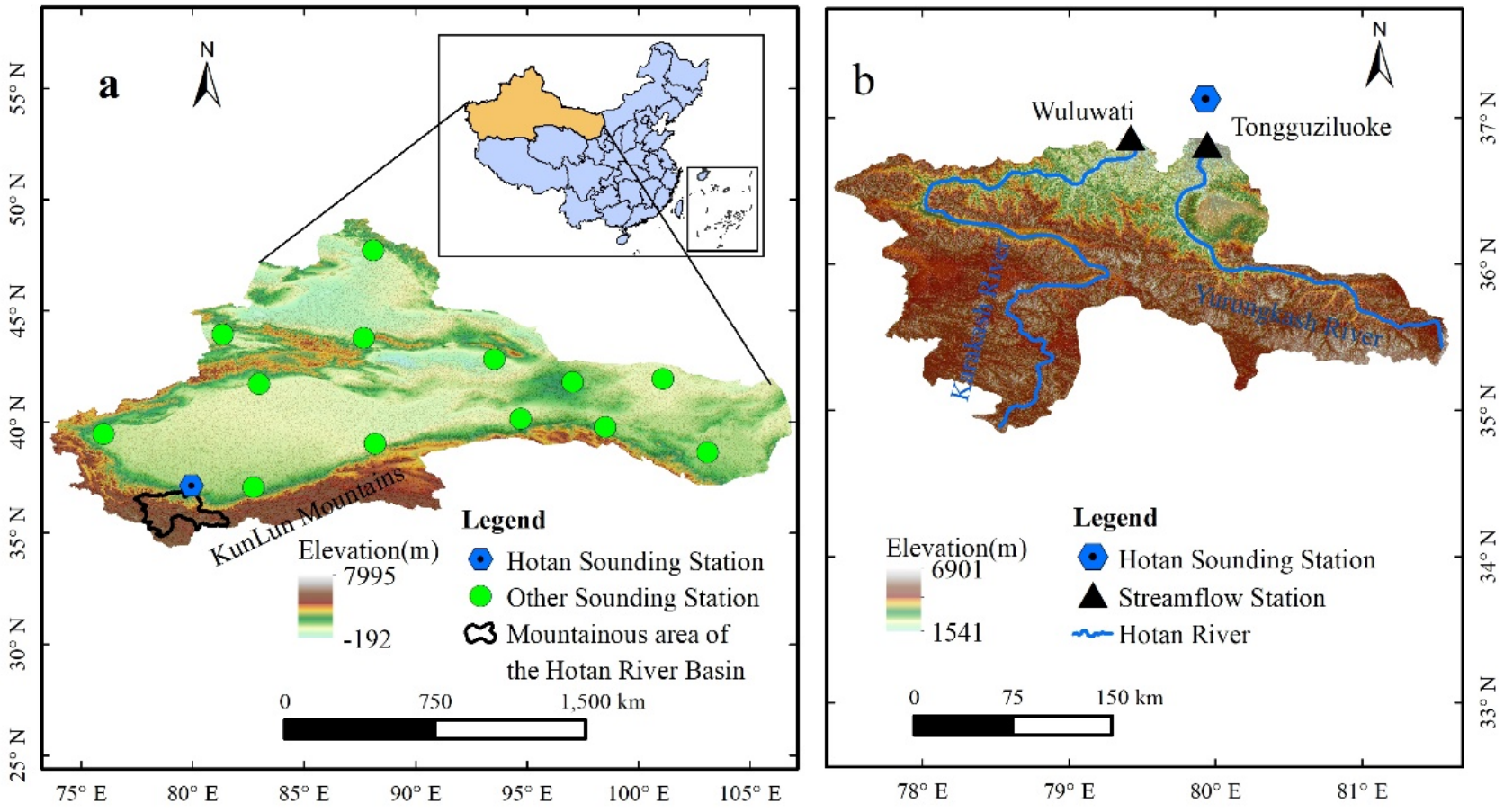
Benchmark method:

multiple linear regression

Simulated effect test:

R^2, *NSC*, *MAE*

3 Study area and Data Sources



- **Runoff (1970-2012):**

The summation of the summer runoff from the mountain pass hydrological stations.

- **Upper-air temperature (UAT) and water vapor (WV)**

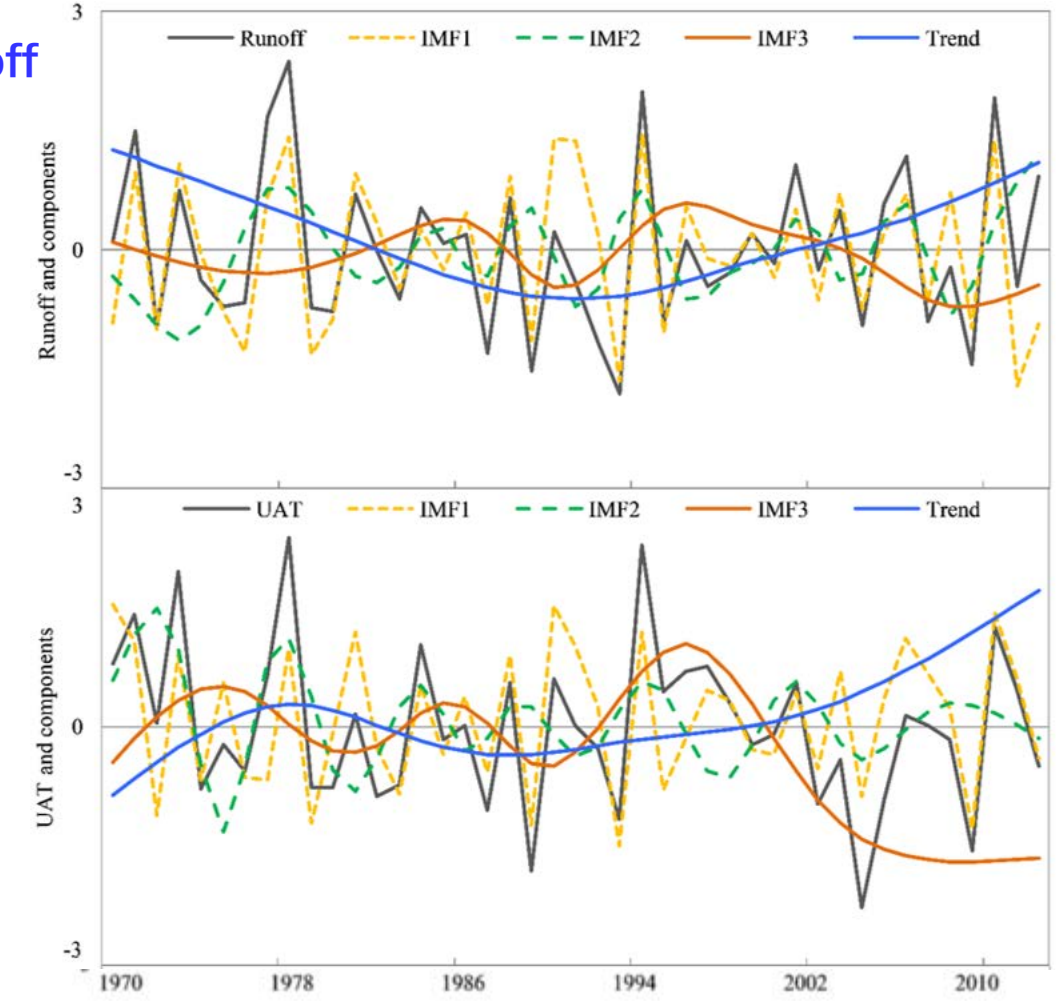
The National Meteorological Administration of China.

- **Irrigation water volume (IV)**

The data are obtained from Zhou et al. (2017).

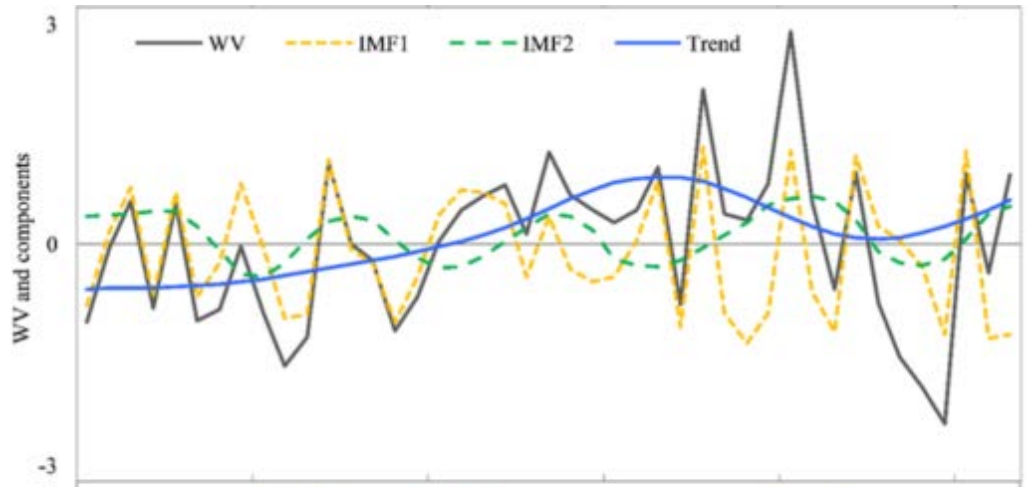
4 Results

Runoff

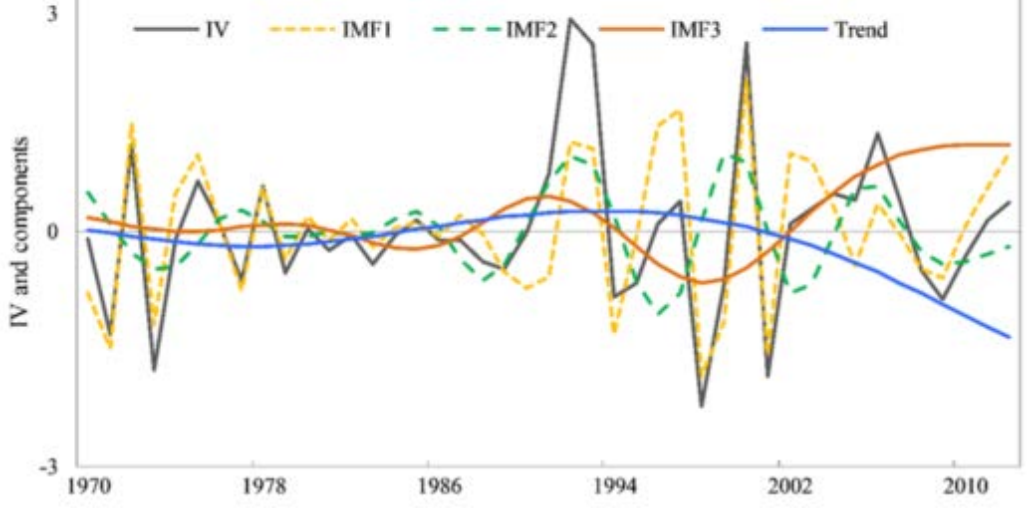


UAT

WV



IV

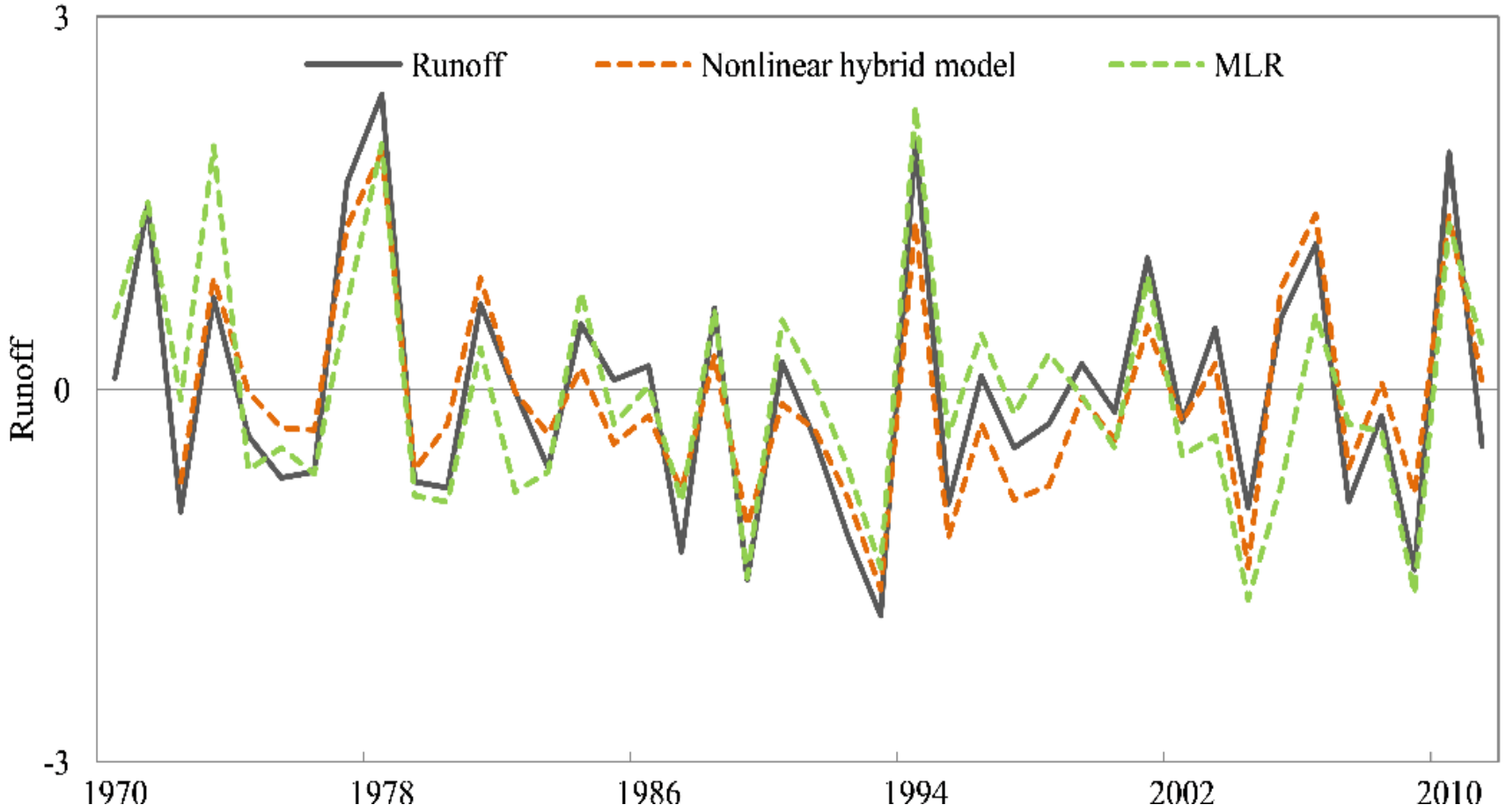


4 Results

The variability explained by each component and associated periods (in brackets) at different time scales.

	IMF1	IMF2	IMF3	Trend
Runoff	53% (2 years)	19% (9 years)	8% (14 years)	20%
UAT	35% (2 years)	15% (6 years)	34% (14 years)	16%
WV	47% (4 years)	36% (11 years)	-	17%
IV	57% (3 years)	18% (10 years)	16% (18 years)	9%

4 Results



Comparison between observed and estimated runoff based on the nonlinear hybrid model and MLR

4 Results

Estimation criteria		R^2 (average)		NSC (average)		MAE (average)	
		Calibration	Validation	Calibration	Validation	Calibration	Validation
Different time scales	Nonlinear hybrid model (**IMF1**)	0.81	0.77	0.79	0.76	0.47	0.52
	Nonlinear hybrid model (**IMF2**)	0.84	0.80	0.81	0.78	0.42	0.45
	Nonlinear hybrid model (**IMF3**)	0.86	0.81	0.83	0.79	0.36	0.39
	Nonlinear hybrid model (**Trend**)	0.87	0.85	0.86	0.83	0.28	0.31
Total	**Nonlinear hybrid model**	0.85	0.83	0.81	0.79	0.35	0.37
	MLR	0.72	0.69	0.70	0.67	0.61	0.65

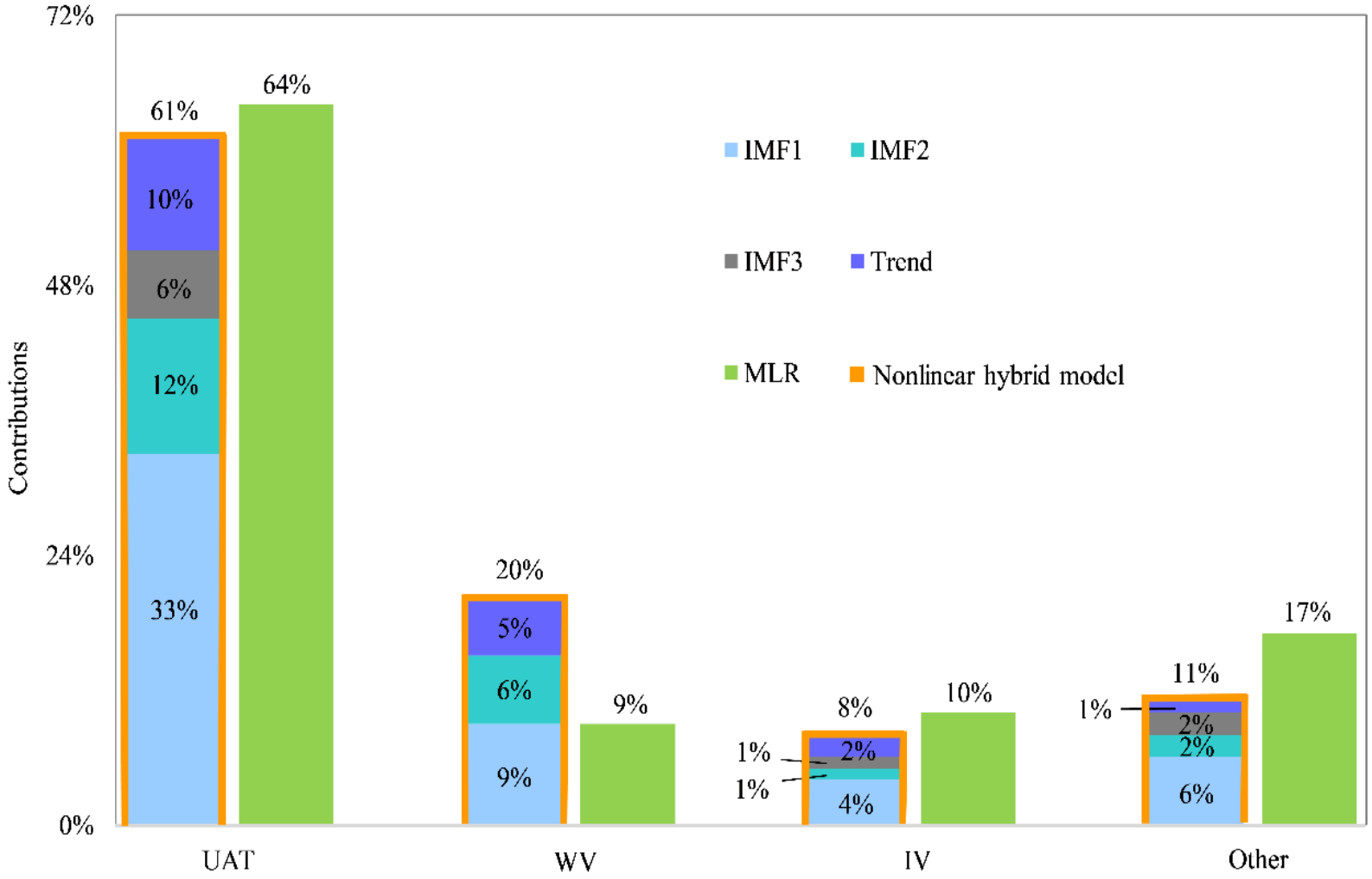
4 Results

Spearman correlation coefficients between runoff and potential drivers at different time scales.

	Observed data	IMF1	IMF2	IMF3	Trend
Runoff and UAT	0.71**	0.69**	0.54**	0.72**	0.66**
Runoff and WV	0.15	0.32*	-0.31*	-	-0.57**
Runoff and IV	-0.31*	-0.27	-0.23	-0.55**	-0.36*

*Significant at $P < 0.05$; **Significant at $P < 0.001$.

4 Results



Contributions of different drivers to runoff variability at different time scales. 'Other' indicates the unexplained variability.

5 Conclusions

- The nonlinear hybrid model outperforms MLR in all performance measures. We attribute this improvement to its ability to represent nonlinear relations and to simulate the driver-runoff relations separately for each time scale.
- Climate variability strongly affects runoff and accounts for 81% of the runoff variation. Human activities play a minor role, accounting for 8% of the runoff variation.

Thank you for your attention!

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