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Multi-risks Analysis Modeling of Cascade Hydropower Station based on System Dynamics

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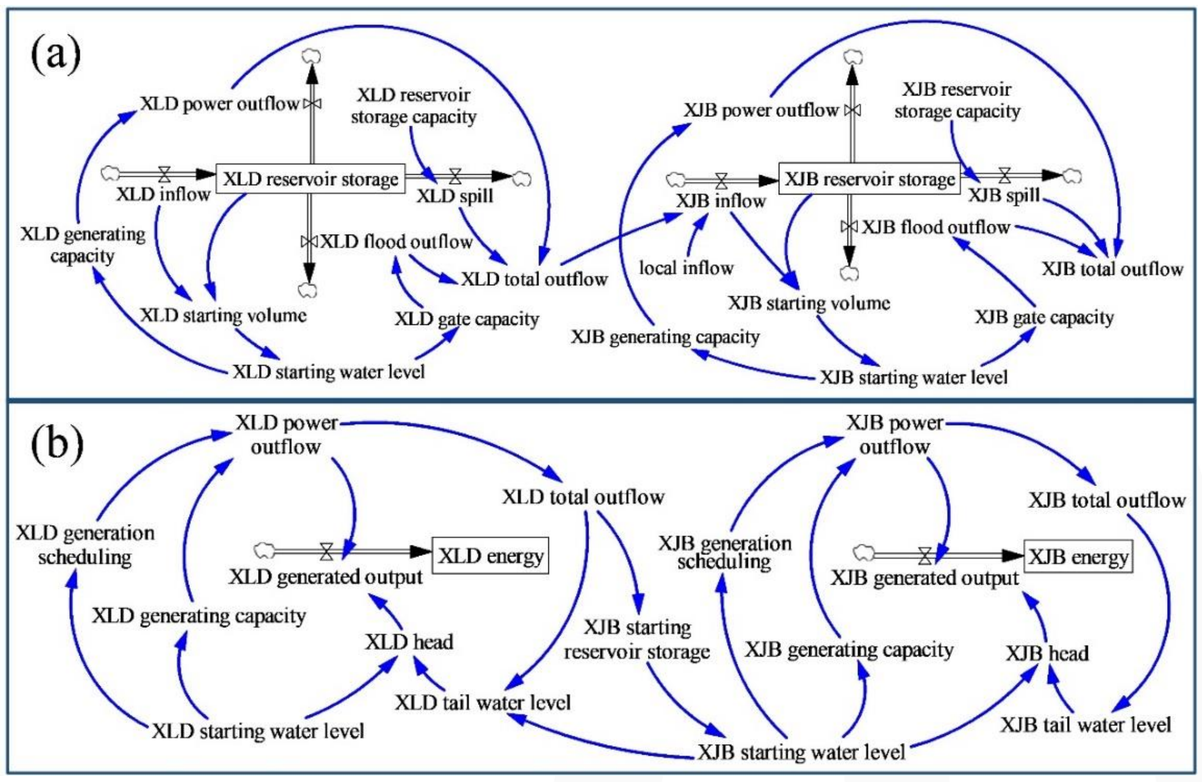
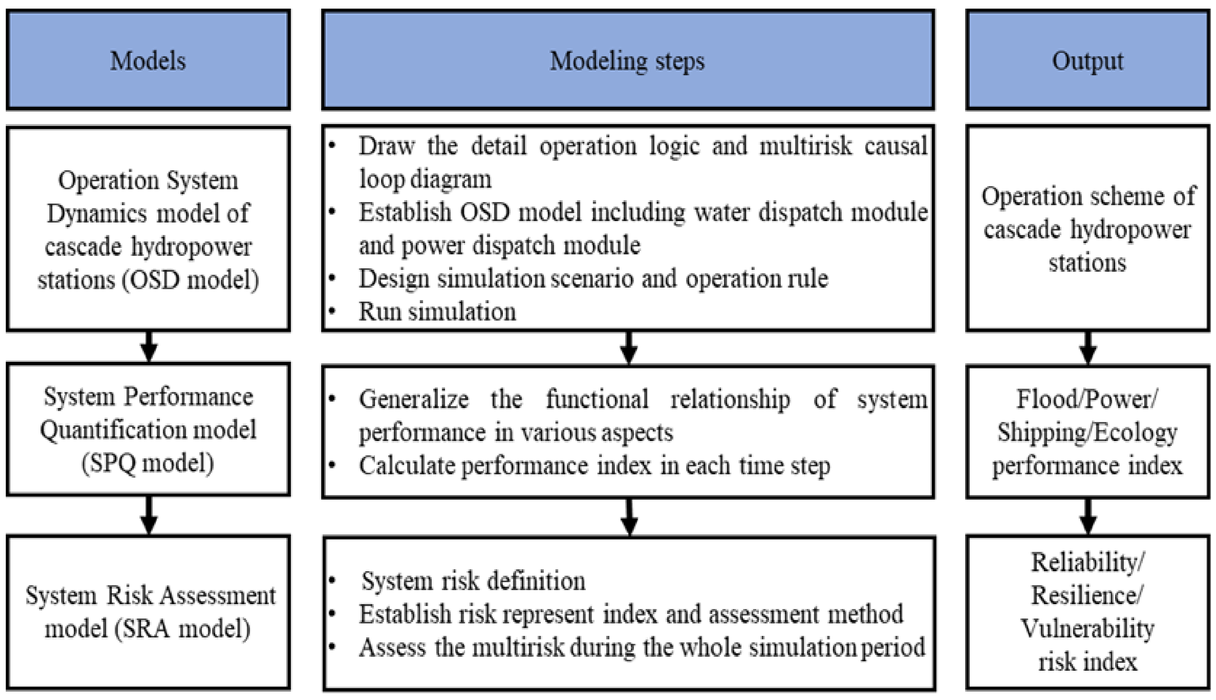
Objectives

- Build a simulation model of cascade hydropower stations that can effectively reflect the dynamic characteristics of the internal operation of the system.
- Propose a multi-risk assessment index system for cascade hydropower stations that can reflect both the possibility of risk occurrence and the consequences of risk accidents;
- Exploring the interactions between multi-risks of cascade hydropower stations;

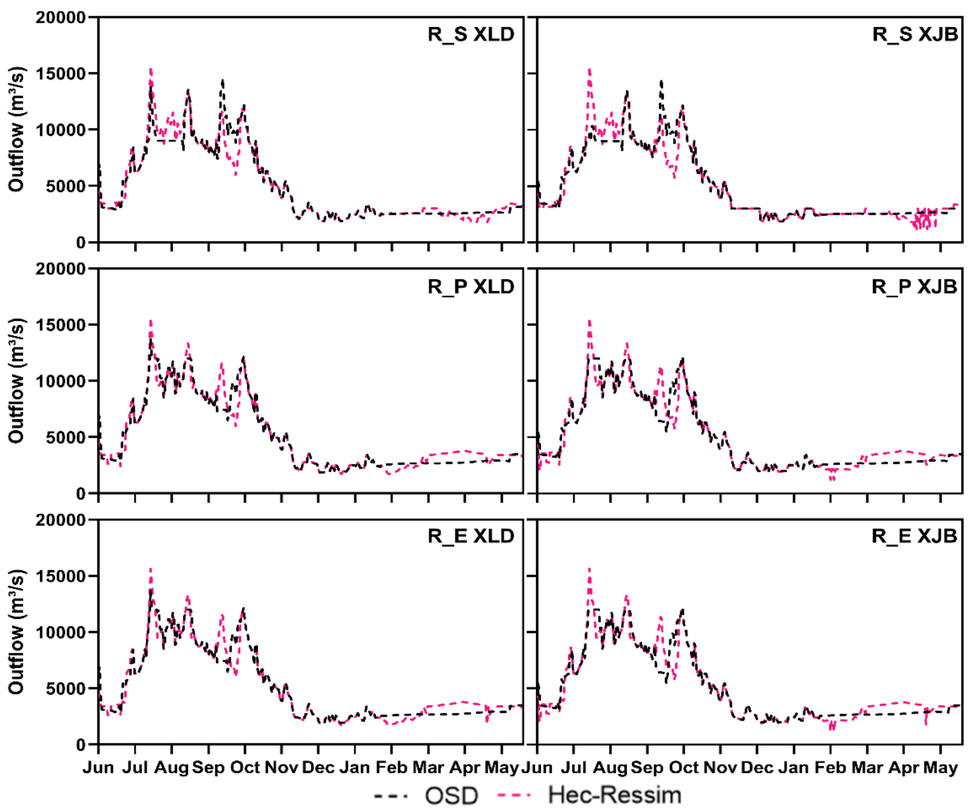


Methods



Results

- The system dynamics model can achieve similar effects to traditional general models.
- By adjusting the priority of different risk control measures, the interrelationships between multi-dimensional risks of cascade hydropower stations can be captured.



Conclusions

- The SD model can accurately simulate the operation process of cascade hydropower stations, and can be used to analyze the dynamic characteristics of system operation. Compared with other general models, the OSD model has the advantages of high intelligibility, operability and expansibility.
- The constructed index system can reflect the multi-risk status of cascade hydropower stations and has a unified dimension, making it suitable for risk assessment methods involving reliability, resilience and vulnerability.
- There is a contradiction between the reliability and vulnerability of the power risk of cascade hydropower stations. Improving the reliability of power risk under insufficient inflow conditions could increase the power generation deficit and shipping risk.
- Controlling ecological risk can help reduce power risk and shipping risk. Therefore, it is suggested to use the ecological outflow for minimum outflow control in the operation of hydropower stations.

Hydrologic characteristics	System	Units	Reliability				Resilience				1-Vulnerability			
			R_0	R_S	R_P	R_E	R_0	R_S	R_P	R_E	R_0	R_S	R_P	R_E
Normal	XLD	Flood	1	1	1	1	1	1	1	1	1	1	1	1
		Power	1	1	1	1	1	1	1	1	1	1	1	1
		Ecology	0.975	1	0.975	1	0.333	1	0.333	1	0.909	1	0.817	1
	XJB	Flood	1	1	1	1	1	1	1	1	1	1	1	1
		Power	1	0.614	1	1	1	0.064	1	1	1	0.800	1	1
		Shipping	0.356	0.666	0.356	0.356	0.051	0.046	0.030	0.051	0.398	0.140	0.288	0.273
		Ecology	0.953	1	0.953	1	0.333	1	0.860	1	0.950	1	0.908	1
	Downstream Flood		1	1	1	1	1	1	1	1	1	1	1	1
Wet	XLD	Flood	1	1	1	1	1	1	1	1	1	1	1	1
		Power	0.597	0.597	0.655	0.584	0.075	0.075	0.127	0.020	0.669	0.669	0.486	0.425
		Ecology	0.734	0.874	0.726	1	0.031	0.022	0.100	1	0.832	0.726	0.769	1
	XJB	Flood	1	1	1	1	1	1	1	1	1	1	1	1
		Power	0.545	0.614	0.578	0.543	0.024	0.064	0.039	0.024	0.836	0.030	0.723	0.509
		Shipping	0.378	0.850	0.378	0.518	0.053	0.063	0.031	0.023	0.358	0.521	0.405	0.221
		Ecology	0.734	1	0.726	1	0.340	1	0.100	1	0.832	1	0.769	1
	Downstream Flood		1	1	1	1	1	1	1	1	1	1	1	1
Dry	XLD	Flood	1	1	1	1	1	1	1	1	1	1	1	1
		Power	0.751	0.751	0.862	0.932	0.121	0.121	0.184	0.357	0.779	0.779	0.643	0.999
		Ecology	0.981	0.981	0.981	1	0.429	0.377	0.429	1	0.933	0.933	0.915	1
	XJB	Flood	1	1	1	1	1	1	1	1	1	1	1	1
		Power	0.893	0.458	0.899	0.964	0.103	0.260	0.162	0.462	0.882	0.150	0.848	0.999
		Shipping	0.258	0.586	0.258	0.356	0.044	0.016	0.026	0.034	0.283	0.277	0.425	0.206
		Ecology	0.981	1	0.981	1	0.429	1	0.429	1	0.933	1	0.915	1
	Downstream Flood		1	1	1	1	1	1	1	1	1	1	1	1