

Supplementary Materials

S1. Hypervolume Indicator

The Hypervolume indicator was first proposed by Zitzler et al., which is the most widely used performance metric in the evolutionary multi-objective optimization community, it is able to evaluate the convergence and the diversity of a solution set simultaneously (Shang et al., 2021). It measures the volume of objective space covered/dominated by the approximation set. The higher the hypervolume of the solution set obtained by an evolutionary multi-objective optimization algorithm, the better the performance of the algorithm. The hypervolume indicator is formally defined as follows (Guerreiro et al., 2021):

Given a point set $S \subset \mathbb{R}^d$ and a reference point $r \in \mathbb{R}^d$, the hypervolume indicator of S is the measure of the region weakly dominated by S and bounded above by r , i.e.,

$$H(S) = \Lambda(\{q \in \mathbb{R}^d \mid \exists p \in S: p \leq q \text{ and } q \leq r\}),$$

where $\Lambda(\cdot)$ denotes the Lebesgue measure. Alternatively, it is interpreted as the measure of the union of boxes:

$$H(S) = \Lambda(\bigcup_{\substack{p \in S \\ p \leq r}} [p, r]),$$

where $[p, r] = \{q \in \mathbb{R}^d \mid p \leq q \text{ and } q \leq r\}$ denotes the box delimited below by $p \in S$ and above by r .

Figure S1 shows an example of hypervolume indicator computed in the space of 2 objective functions.

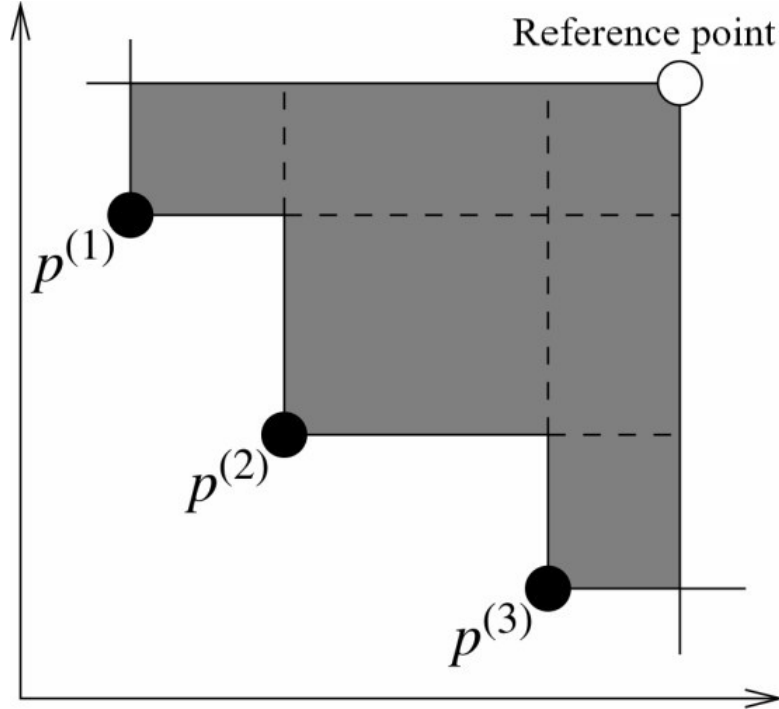


Figure S1. The hypervolume indicator in the two-objective case (Adapted from Fonseca et al., 2006).

Table S1. Land use types and their codes in the vegetation database.

ID	Category Code in SWAT	Landuse
1	AGRL	Cropland
6	FRST	Mixed forest
8	FRSE	Evergreen forest
15	RNGE	Grassland
16	RNGB	Shrub
17	SWRN	Sparse forest/shrub/grass
33	RICE	Paddy field

Table S2. Nash–Sutcliffe efficiency (NSE) for the flow duration curves (FDC) in three case studies.

Case Studies	Ningdu	Shicheng	Fenkeng
Multi-site	0.97	0.74	0.93
Multi-variable	0.90	0.52	0.97
Multi-objective functions	/	/	0.66

* The calculation of NSE for the FDC is referenced from Gharari et al. (2014).

Table S3. Simulation accuracy (NSE) for the three case studies.

Case Studies	Ningdu		Shicheng		Fenkeng		ET	
	Cal	Val	Cal	Val	Cal	Val	Cal	Val
Multi-site	0.68	0.75	0.55	0.66	0.63	0.61	/	/
Multi-variable	0.77	0.81	0.51	0.47	0.77	0.79	0.29	0.30
Multi-objective functions	/	/	/	/	0.70	0.71	/	/

* Cal and Val denote calibration and validation, respectively.

Reference

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- Fonseca, C. M., Paquete, L., López-Ibáñez, M., & Ieee. (2006, Jul 16-21). *An improved dimension-sweep algorithm for the hypervolume indicator*. Paper presented at the IEEE Congress on Evolutionary Computation, Vancouver, CANADA.

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