Estimating evaporation in Taihu based on isotopic mass balance model

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Contents

1. Background

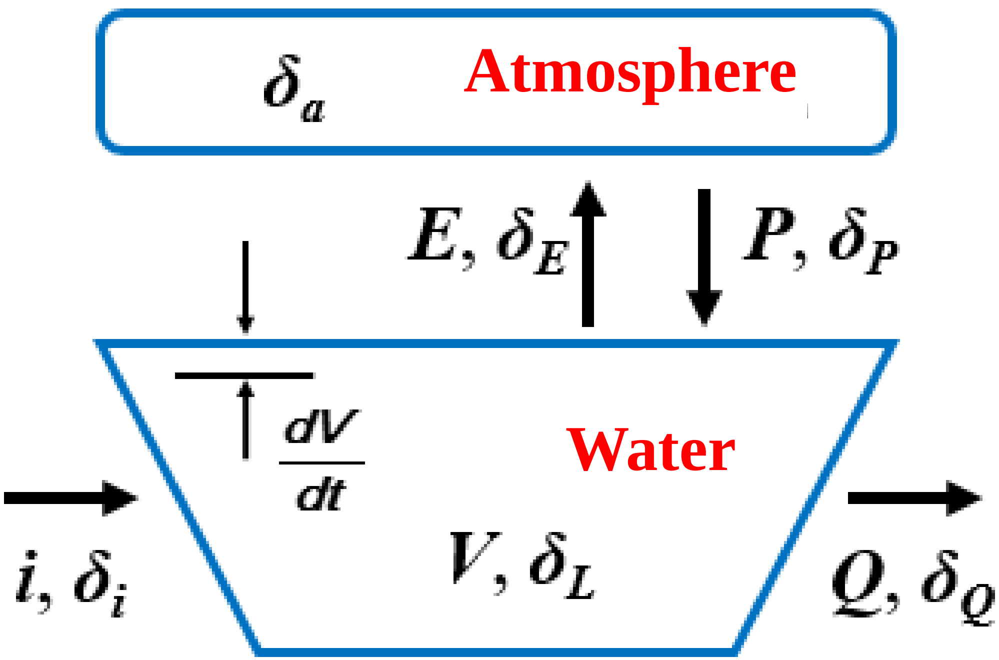
- As the most ideal natural tracer, $^{1}H^{2}H^{16}O$ and $^{1}H_2{}^{18}O$ are widely used in studies of the regional hydrologic cycle for local meteorology and hydrology, such as evaporation rate.（Edwards et al., 2005； Yakir et al., 2000）

- Isotopic mass balance model has been widely applied in many inland lakes to assess evaporative losses (Lake Titicaca — Zuber, 1983; Mediterranean Sea — Gat *et al*., 1996; Lake Biwa — Taniguchi *et al*., 2000; Lake Edward — Russell and Johnson, 2006; Lake Okanagan — Wassenaar *et al*., 2011).

- In this study, we estimated evaporation in Taihu based on isotopic mass balance to explore the isotope enrichment mechanism of a subtropical large shallow lake.

2. Experimental method

2.1 Isotopic mass balance model



$$I = E + Q + \frac{dV}{dt} \quad (I = i + p)$$

$$+$$

$$I\delta_I = E\delta_E + Q\delta_Q + \frac{\mathrm{d}(V\delta_L)}{dt}$$

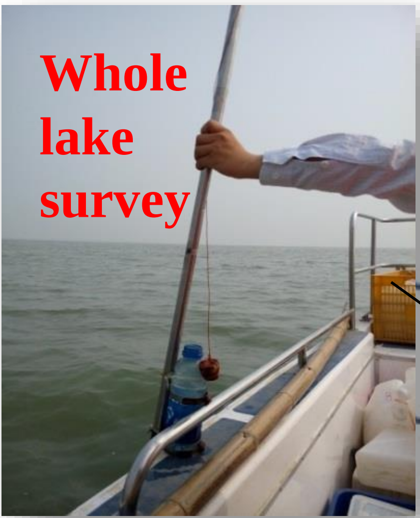
$$\downarrow$$

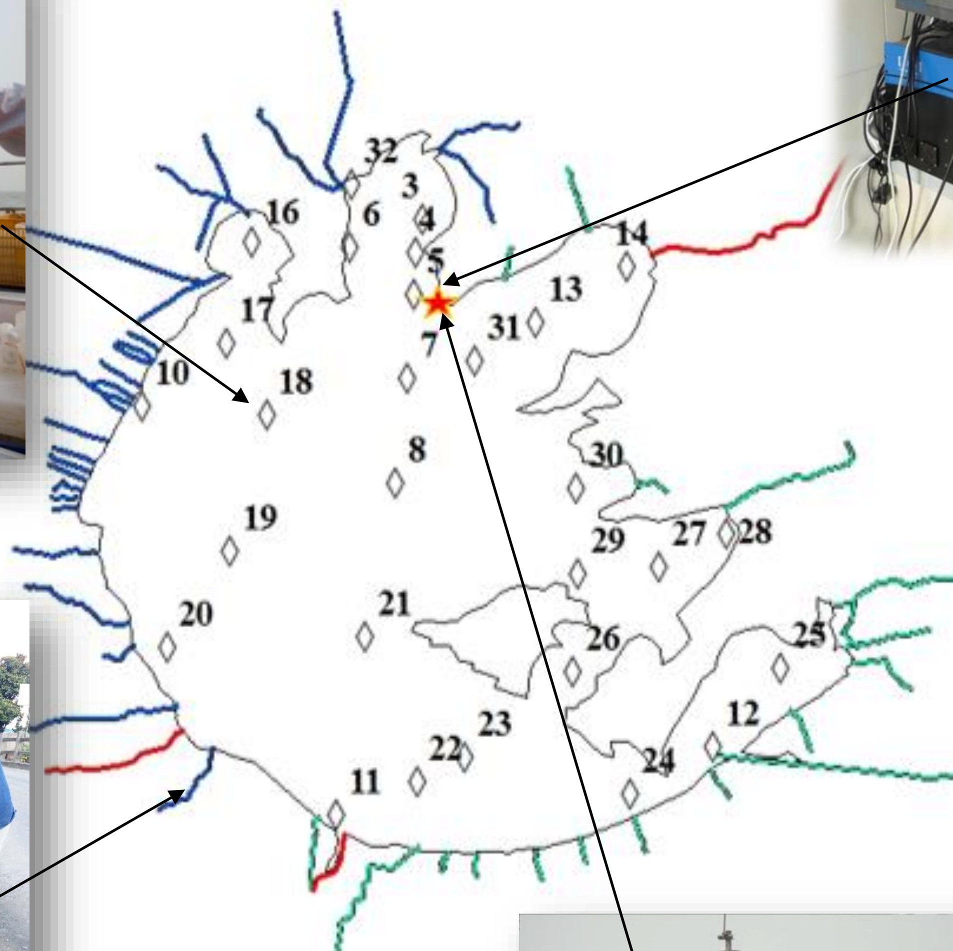
$$E = \frac{V\frac{d\delta_L}{dt} + (\delta_L - \delta_Q)\frac{dV}{dt} + I(\delta_Q - \delta_I)}{\delta_Q - \delta_E}$$

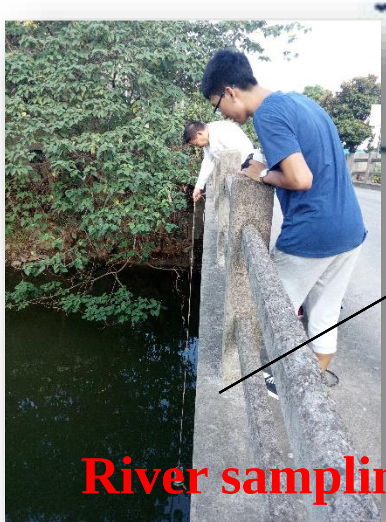
$$\delta_E = \frac{\alpha_{eq}^{-1}\delta_L - h\delta_V - \varepsilon_{eq} - (1-h)\varepsilon_k}{1 - h + 0.001(1\text{-}h)\varepsilon_k}$$

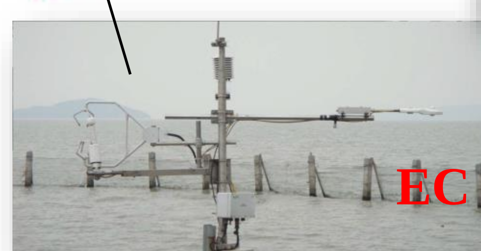
C-G model

2.2 Sampling and data









3. Results and discussion

- **3.1 Results of isotopic mass balance and comparison**
- **3.2 Slope of local evaporation line (S_{LEL})**
- **3.3 Sensitivity analysis of isotopic mass balance**

3.1 Results of isotopic mass balance and comparison

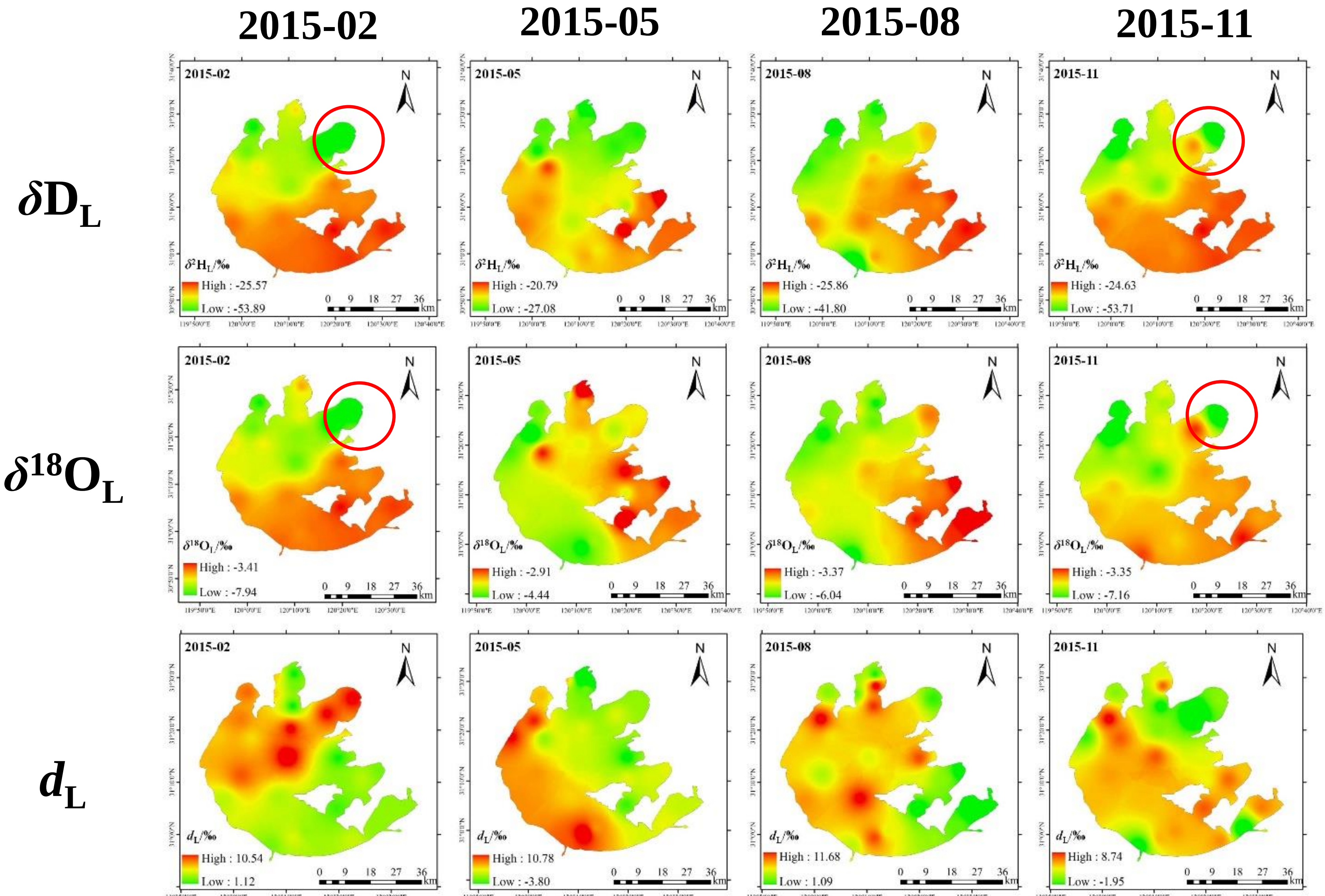
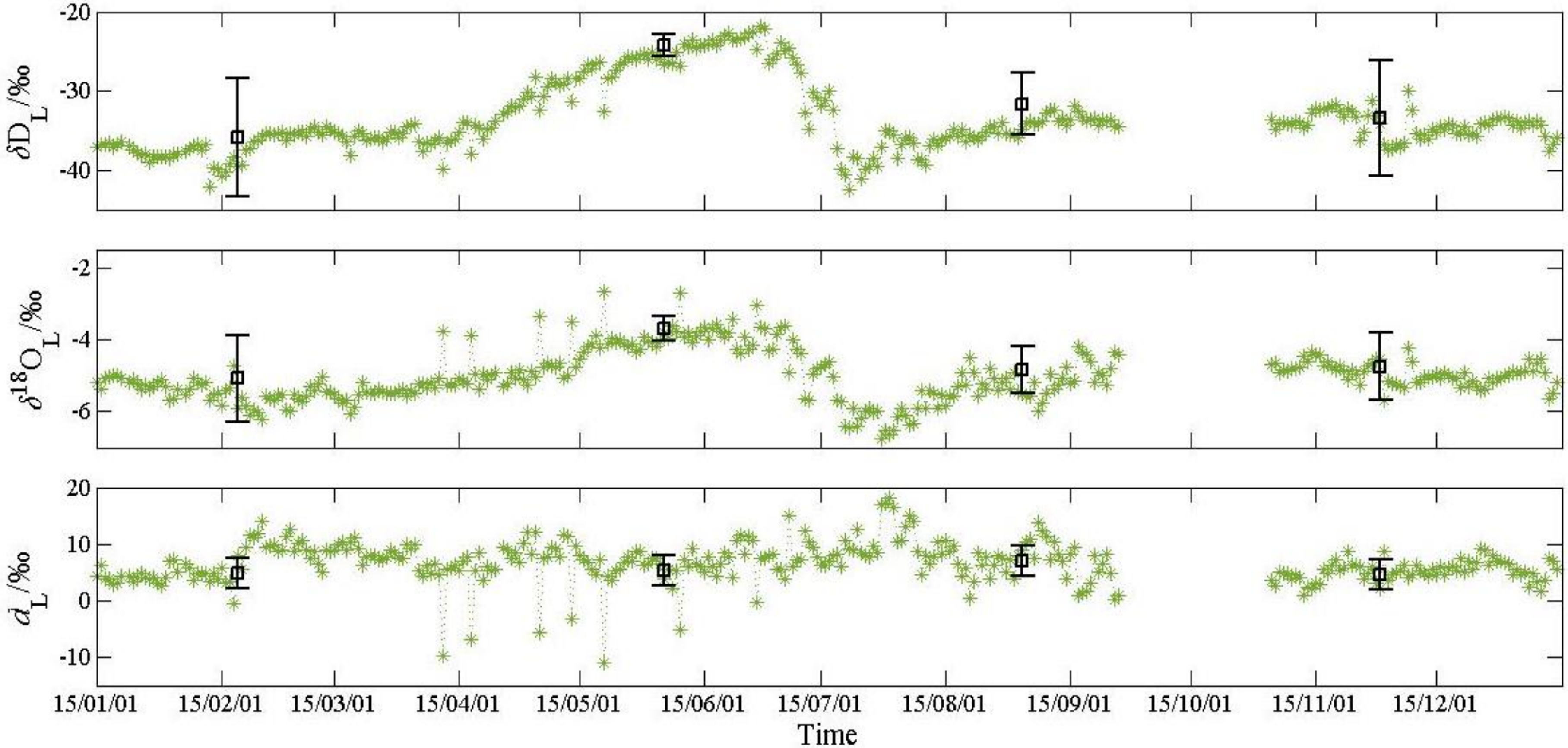


Fig.1 Spatial distribution of lake water isotope composition in Taihu, 2015



+： daily water in MLW; □： whole lake water survey

Fig.2 Temporal variation of lake water isotope composition in Taihu, 2015

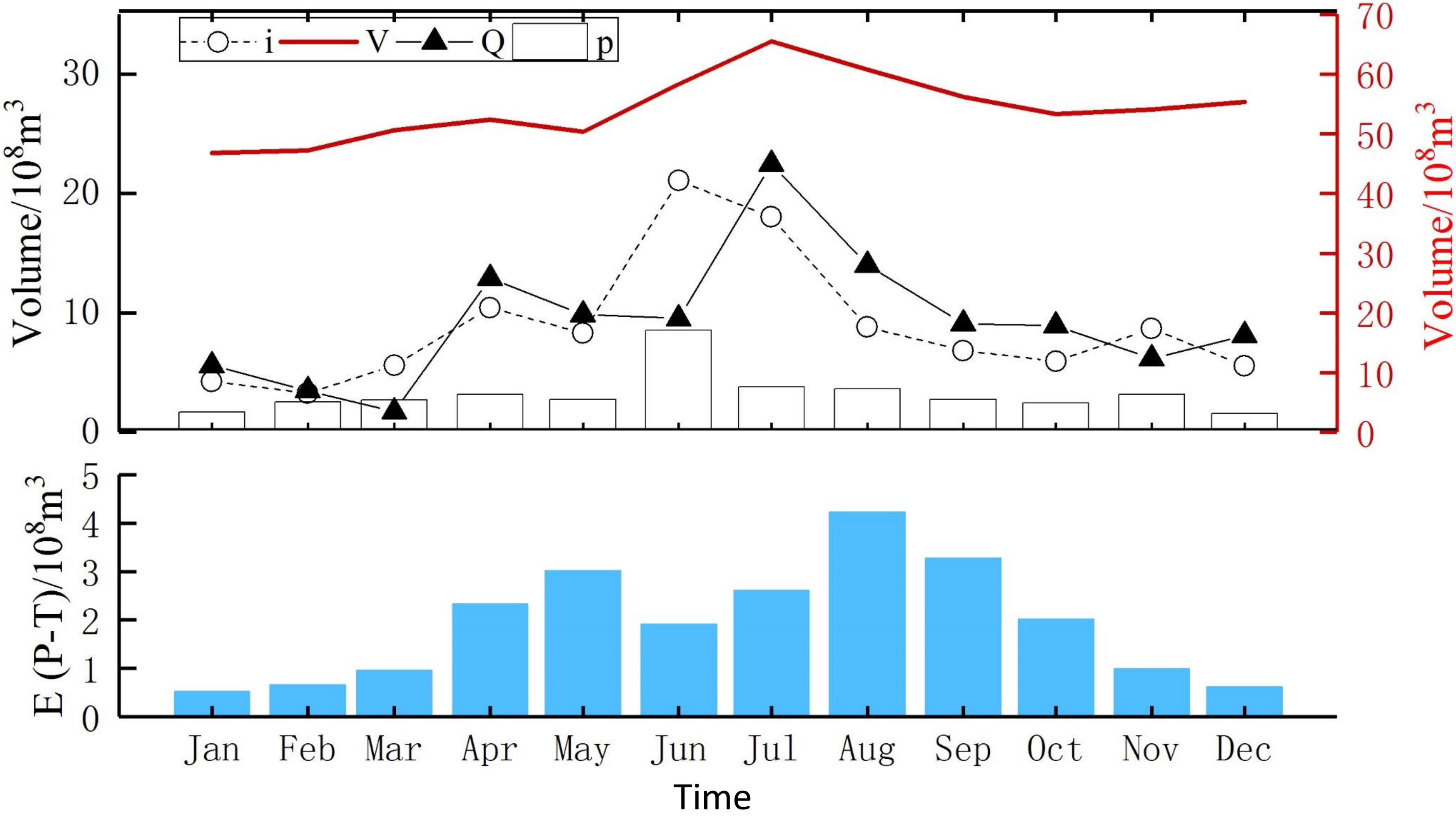


Fig.3 Temporal variation of different water amounts in Taihu

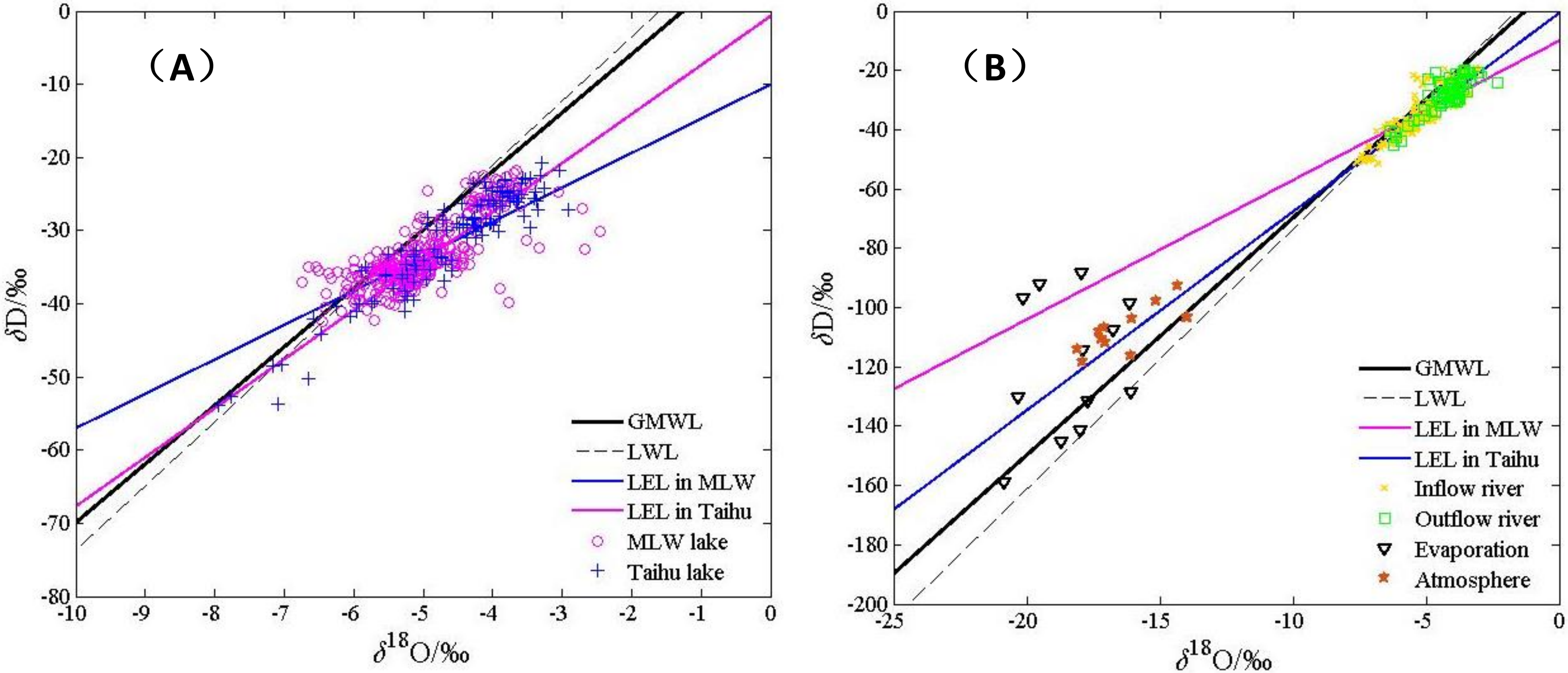


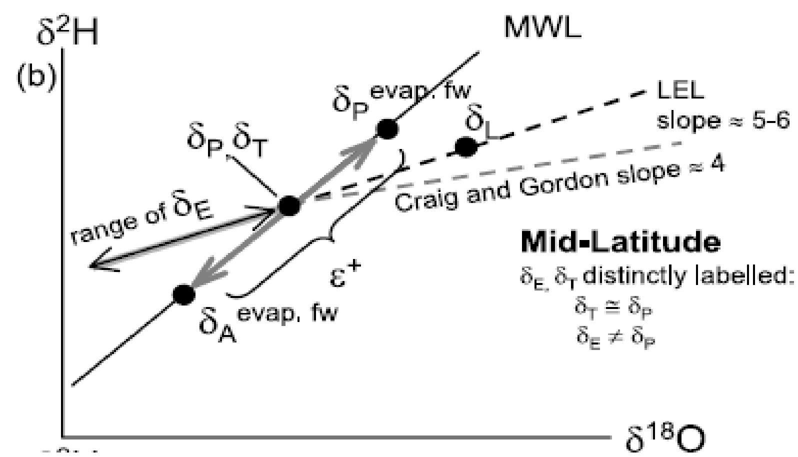
Fig.4 The relations between δ^2H and δ^{18}O in different water of lake Taihu.

GMWL: $\delta^2H=8.17\delta^{18}O+10.56$;

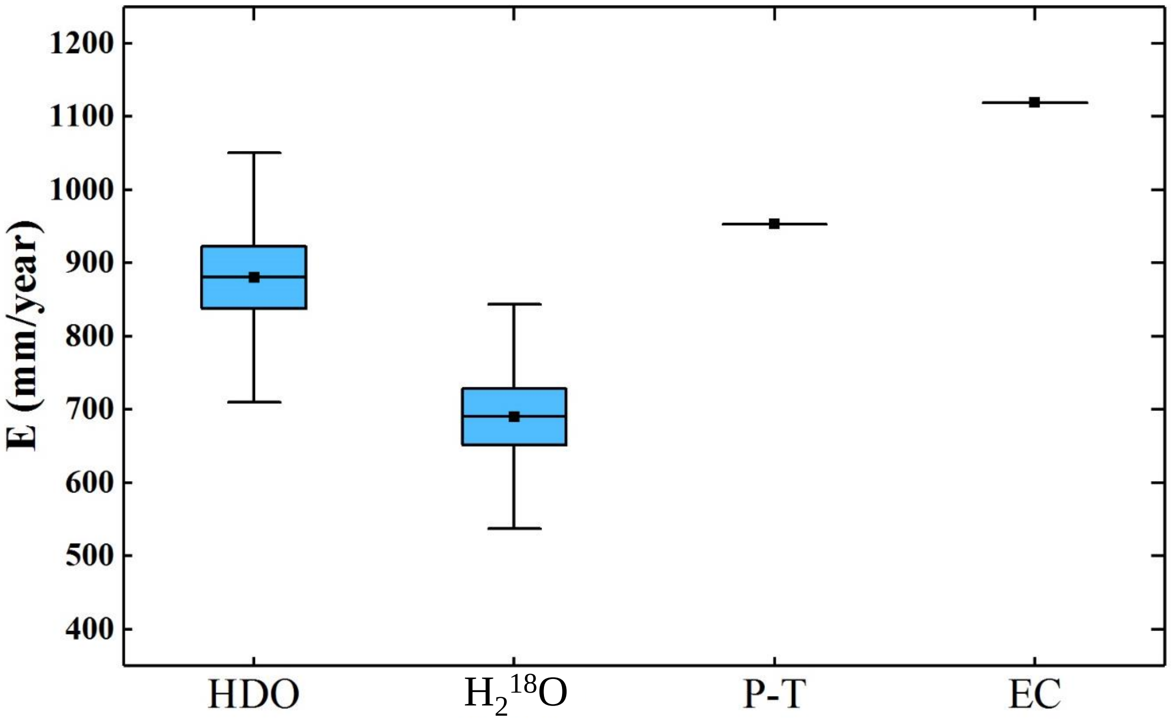
LWL: $\delta^2H=8.77\delta^{18}O+13.96$;

LEL in MLW: $\delta^2H=4.80\delta^{18}O-9.4$, $R^2=57\%$;

LEL in Taihu: $\delta^2H=6.66\delta^{18}O-0.71$, $R^2=87\%$.



(Gibson *et al*., 2008)



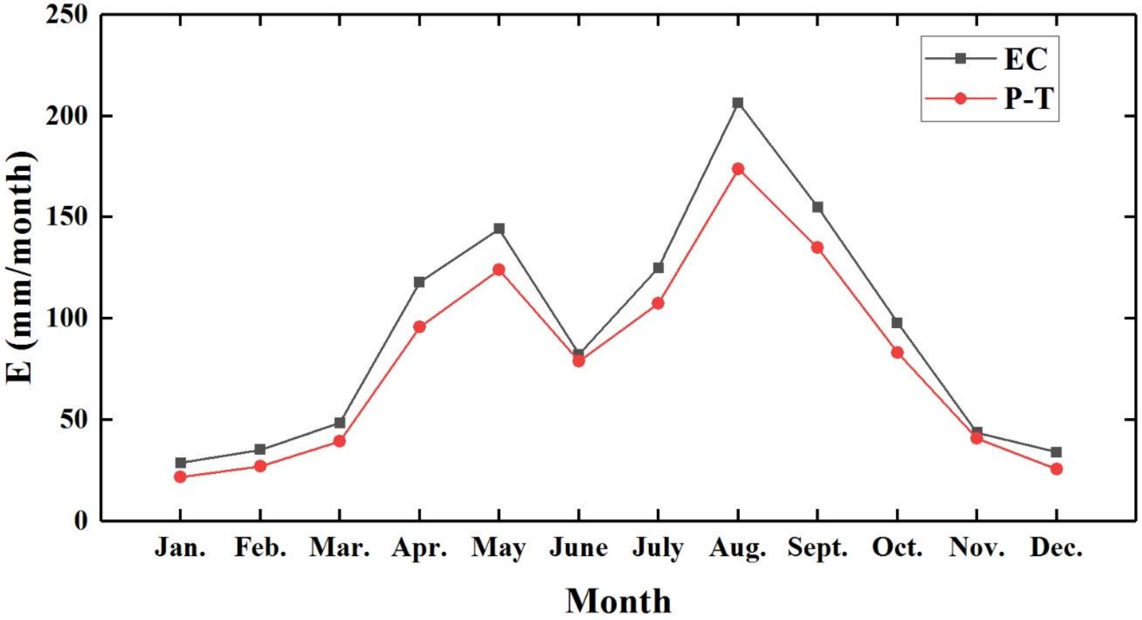


Fig.5 Comparison of calculated evaporation between different methods.

3.2 Slope of local evaporation line

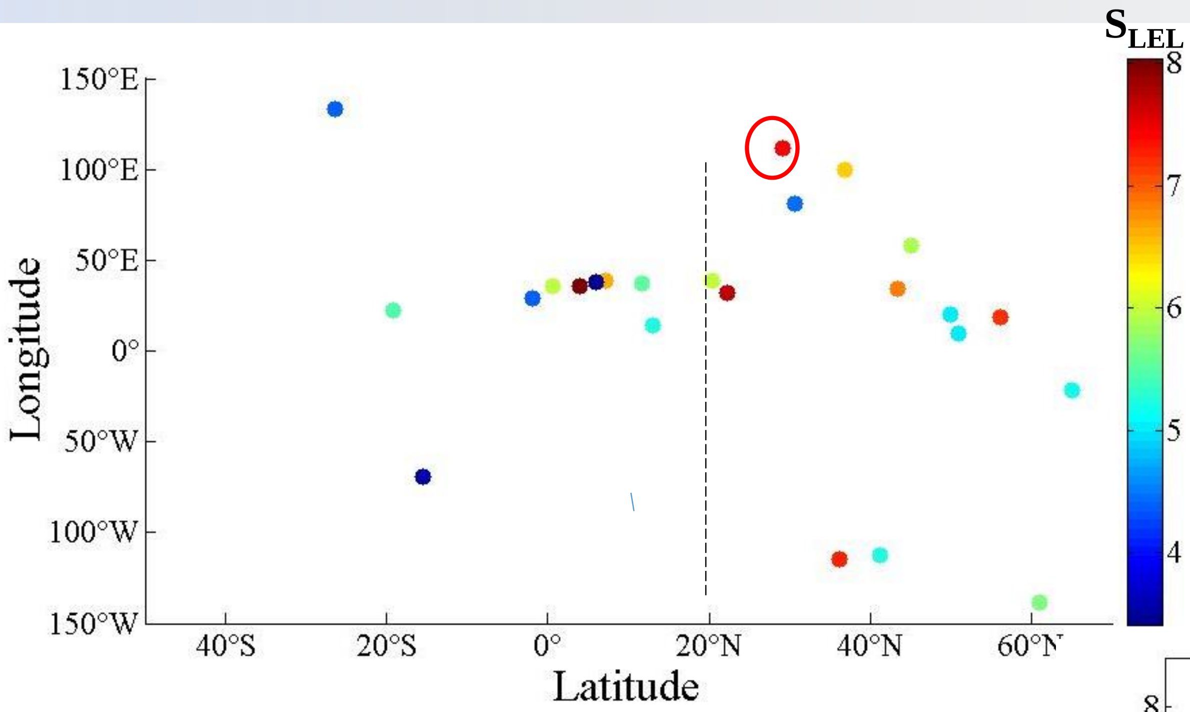
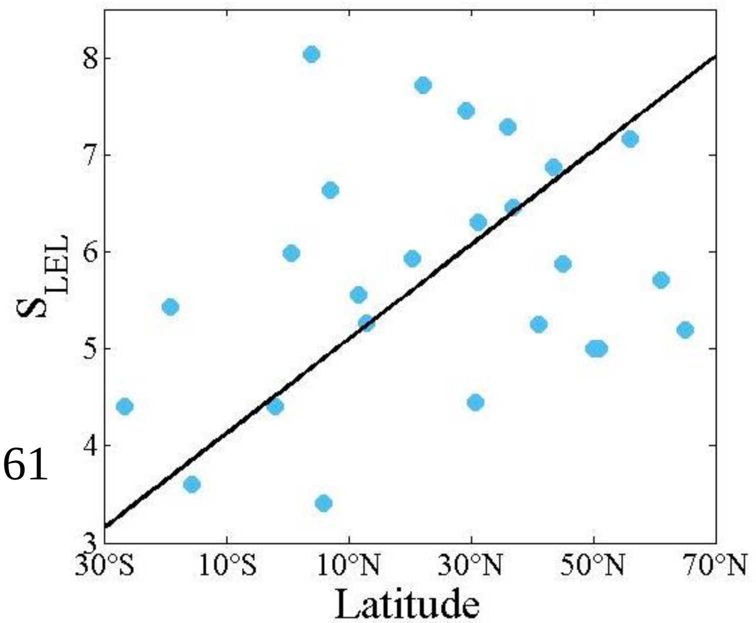


Fig.6 Relation between $\mathbf{S_{LEL}}$ and latitude.

y = 0.05x+4.61
R^2= 7.84%



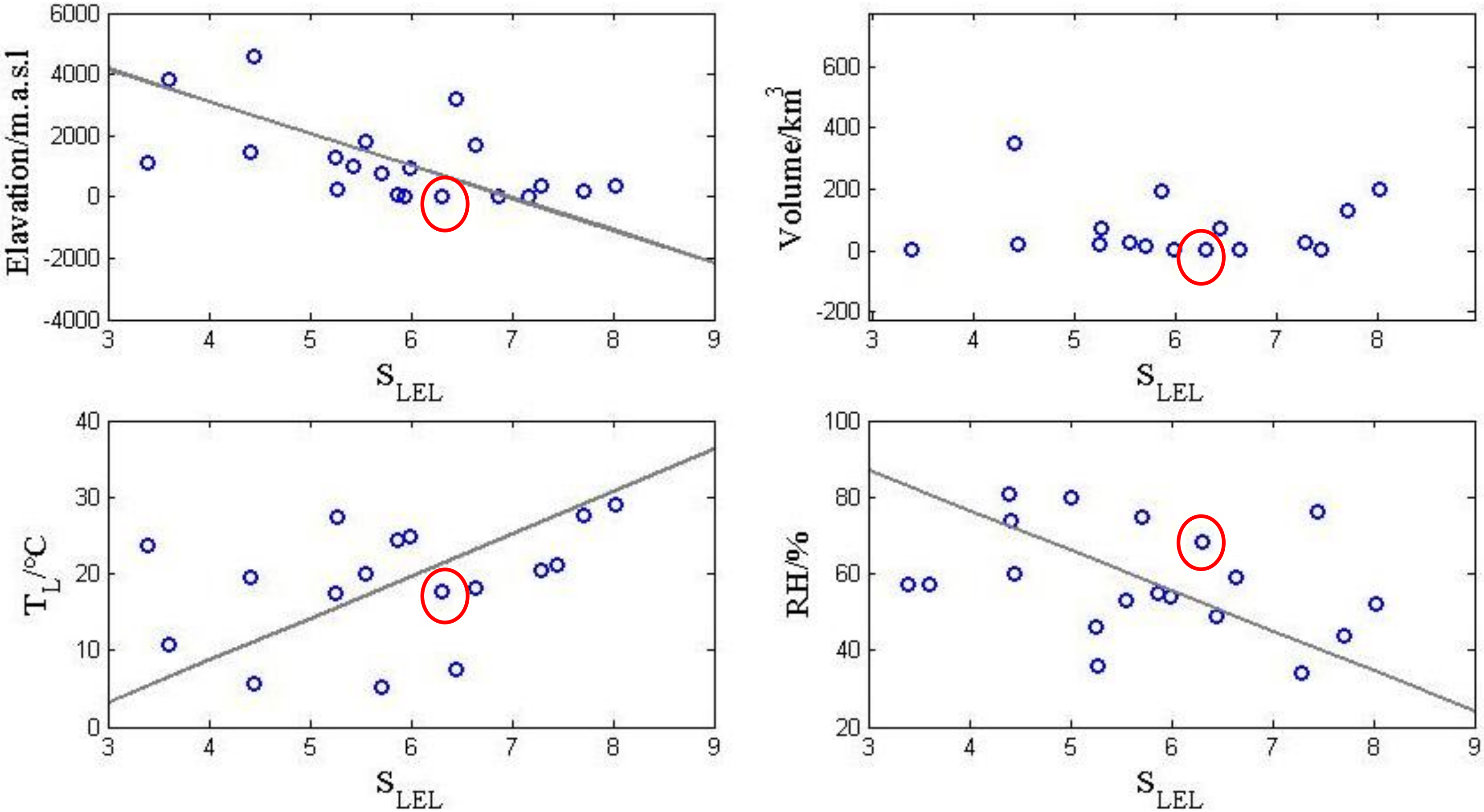


Fig.8 Relation between $\mathbf{S_{LEL}}$ and lake environment factors.

3.3 Sensitivity analysis

Table 1. The influence of parameters in isotopic mass balance method on evaporation.

	ΔE (HDO) mm/year		ΔE ($H_2^{18}O$) mm/year	
	Δ=±5%	Δ=±10%	Δ=±5%	Δ=±10%
δ_I	±16.17%	±32.35%	±17.47%	±34.98%
δ_Q	±9.22%	±18.50%	±10.54%	±21.08%
δ_L	±0.65%	±1.33%	±0.76%	±1.46%
δ_E	±6.78%	±13.72%	±6.55%	±13.22%
I	±11.57%	±23.18%	±12.67%	±25.39%
V	±0.50%	±0.95%	±0.26%	±0.75%
dV/dt	±0.08%	±0.12%	±0.03%	±0.13%
$d\delta_L/dt$	±0.48%	±0.97%	±0.26%	±0.53%

4. Conclusions

1. In 2015, the spatial distribution of δD_L and $\delta^{18}O_L$ in lake water was controlled by water flow direction, causing isotopic enrichment in the southeast of lake. On yearly time-scale, a seasonal regularity was that δD_L and $\delta^{18}O_L$ were poor in winter and enriched in spring.

2. The evaporation amounts of Taihu in 2015 calculated by isotopic mass balance method were 880.56±42.60 mm (HDO) and 689.93±37.86 mm ($H_2{}^{18}O$). Within a certain error range, this method was suitable for large shallow lakes for evaporation capacity calculation.

3. The S_{LEL} of Taihu arrived at 6.66 during 2015 mainly for high humidity and temperature, besides its low elevation.

4. The precision of result in isotopic mass balance method mainly depended on the accuracy of δ_E, Through simulated by HDO which was less sensitive to δ_E, the evaporation result of Taihu was clsoe to other evaporation model calculation results.

5. Next work

- Through reading articles, find out a deeper difference between HDO and $H_2^{18}O$ for application the isotopic mass balance model.

- Apply the isotopic mass balance model to small fishpond without inflow or outflow, then quantify parameters in the C-G model.

Thank you for suggestions!