Refined comparison of pan evaporation, eddy covariance, and evaporation model for Lake Taihu

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Outline

- Background
- Methods and Materials
- Results and Discussion
- Conclusion

Background

- Eddy covariance method is the most direct way to measure the heat ,vapor and other gas flux, it is a good way to validate various models.

- Because of the short period of EC operation, lake models and pan evaporation can be used as tracer to show the historical lake evaporation.

Energy imbalance

- $$R_n - \Delta Q \overset{?}{\Rightarrow} H + LE$$

- $$\begin{cases} LE' + H' = R_n - \Delta Q \\ \dfrac{H'}{LE'} = \dfrac{H}{LE} = \beta \end{cases}$$

(Twine et al., 2000)
(Wang et al., 2014)

Table 1

Annual mean net radiation, heat storage and energy fluxes from Jan 2012 to Dec 2012.

Site	Rn (W m^{-2})	Heat storage (W m^{-2})	H (W m^{-2})		LE (W m^{-2})		β
			Pre-closure	Post-closure	Pre-closure	Post-closure	
BFG	86.5	-2.1	6.6	8.7	55.4	80.0	0.11
DPK	89.9	0.2	6.8	8.3	73.0	82.2	0.10

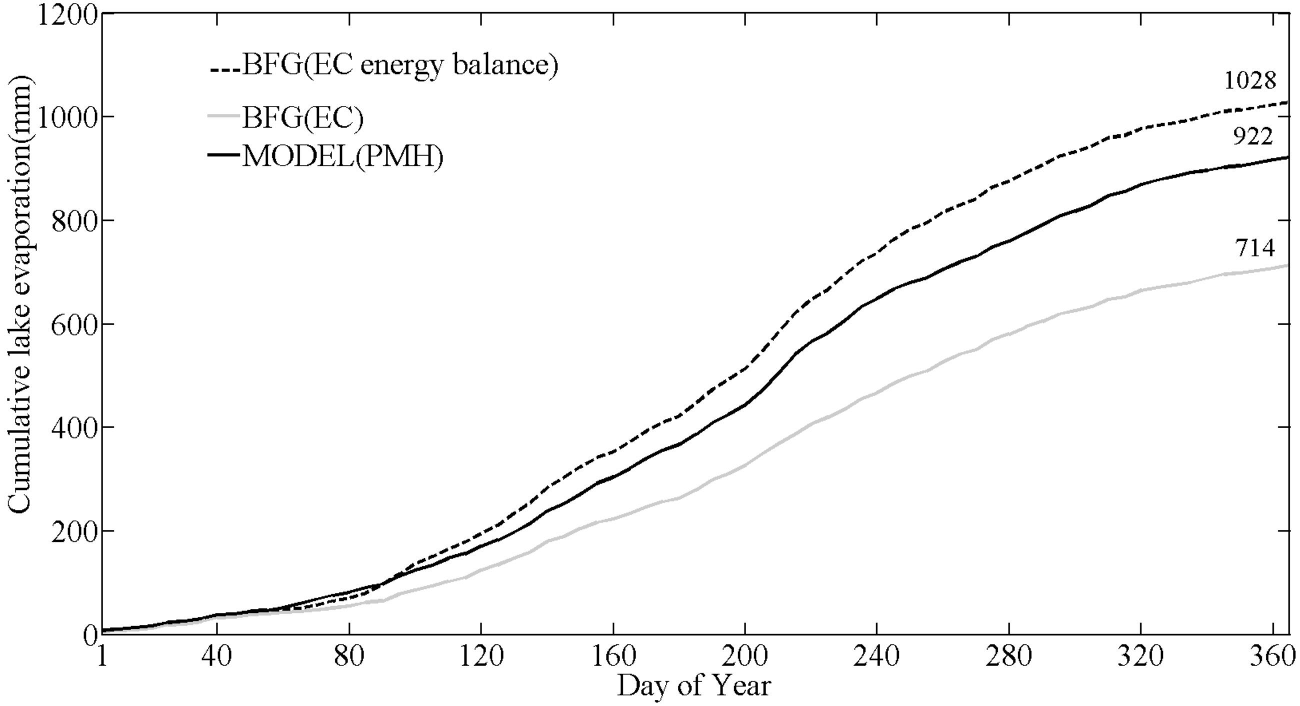


Fig.1. Cumulative lake evaporation of 3 results-EC observation forcing energy closure (black dotted line), EC observation without forcing energy closure (black solid line), and modeled (PMH) (gray solid line).

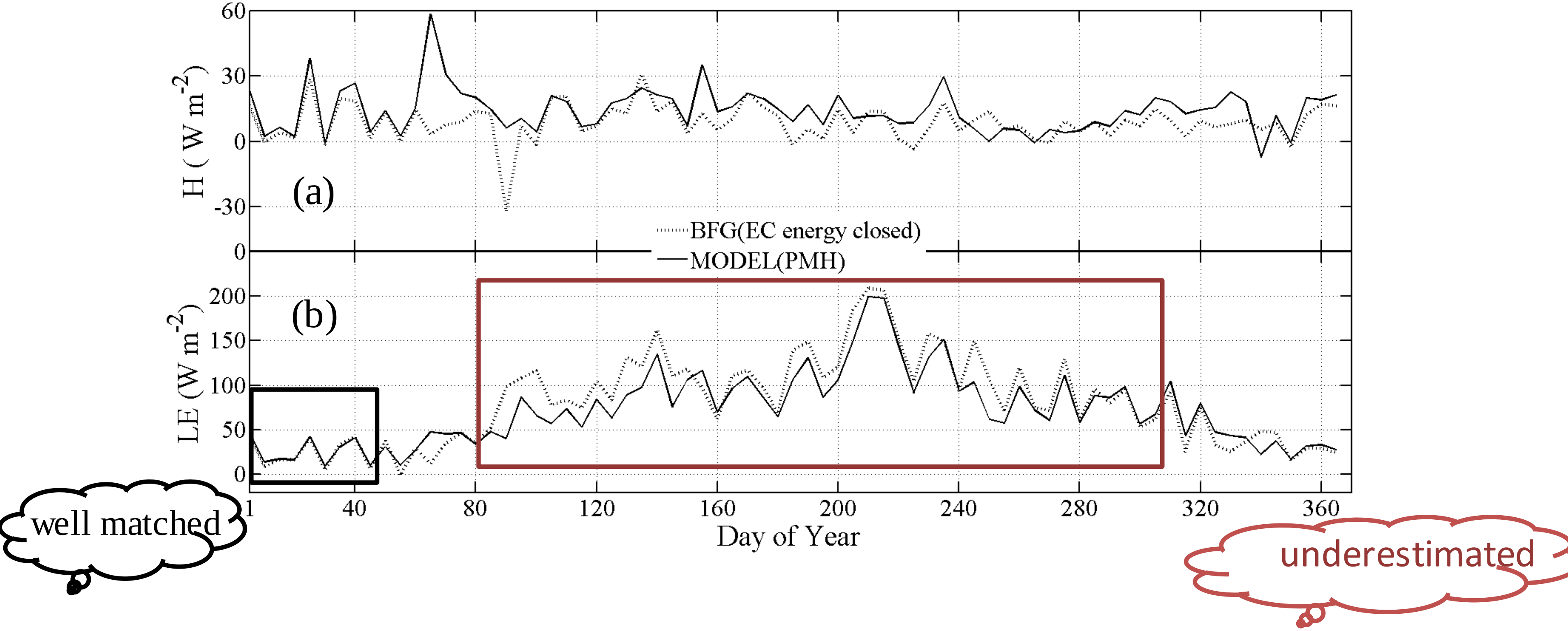


Fig.2. Time series of (a) sensible heat flux (H) , (b)latent heat (LE) , comparison of EC flux and modeled flux (untuned model) , all the results are averaged in 5 days period.

Table 2

Parameters in CLM4-LISSS model, with η, β, k_e, Z_{0m}, Z_{0h}, Z_{0q} represent the fraction of net short-wave radiation retained in the lake surface layer, light extinction coefficient, eddy diffusivity, momentum roughness length, thermal roughness length and water vapor roughness length respectively.

Parameter	Deng et al.	Piao				Tuned	
		Spring	Summer	Autumn	Winter	Winter	Others
$\eta(m^{-1})$	5	3	2.5	2.5	3	3	2.5
$\beta(\%)$	63.2	45.1	39.3	39.3	45.1	45.1	39.3
$k_e(m^2 s^{-1})$	0.02	0.02	0.14	0.11	0.02	0.02	0.02
$Z_{0m}(m)$	3.3×10^{-4}	1.9×10^{-6}	1.9×10^{-6}	6×10^{-5}	1.9×10^{-7}	1.9×10^{-7}	2.1×10^{-4}
$Z_{0h}(m)$	1.9×10^{-6}	8×10^{-5}	8×10^{-5}	8×10^{-5}	8×10^{-5}	8×10^{-5}	8×10^{-5}
$Z_{0q}(m)$	3.9×10^{-8}	3.9×10^{-8}	3.9×10^{-8}	3.9×10^{-8}	3.9×10^{-8}	3.9×10^{-8}	3.9×10^{-8}

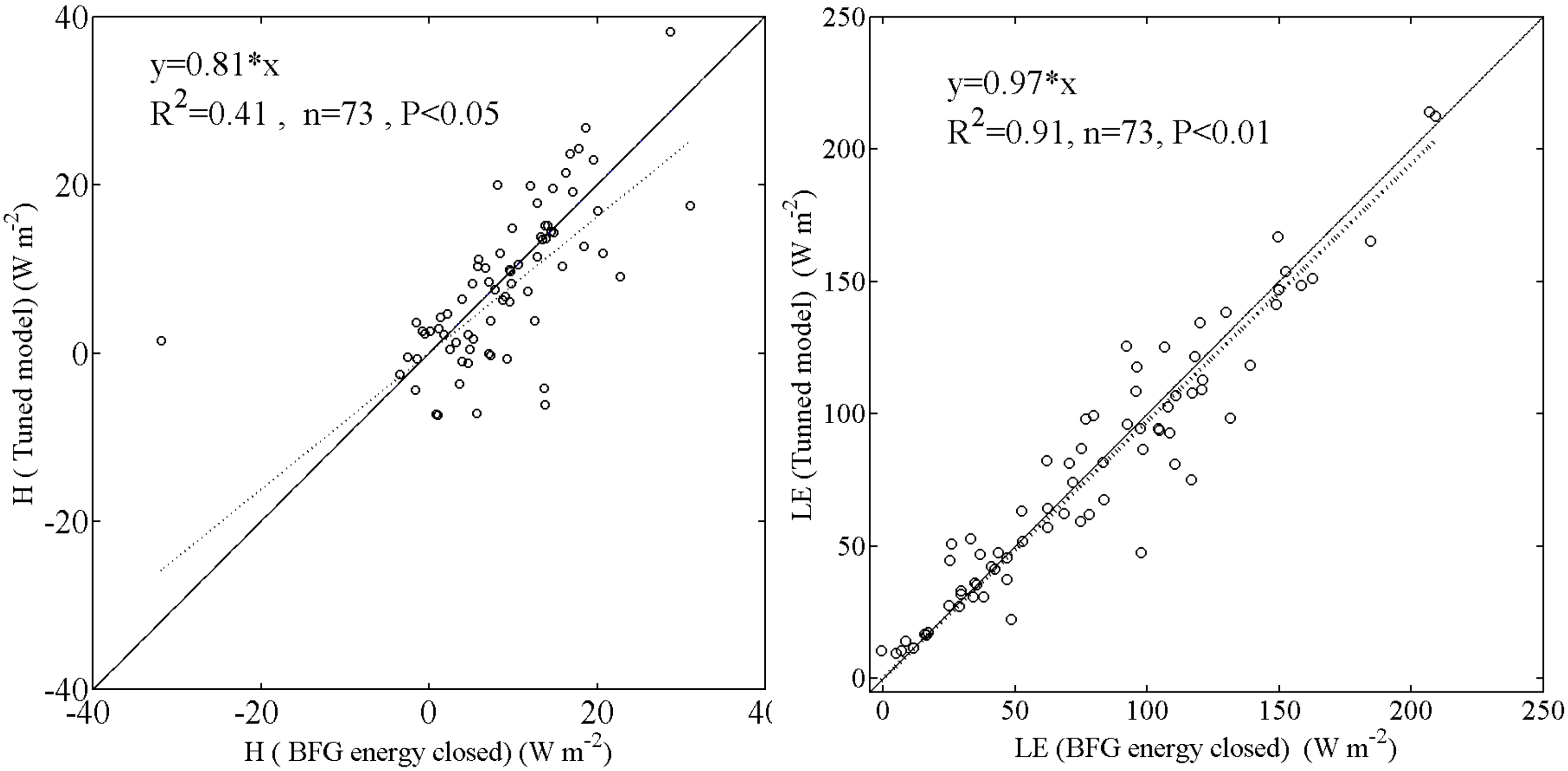


Fig.3. Comparison between the measured (BFG) and modeled (tuned) sensible heat (a, left), latent heat (b, right) from Lake Taihu 2012.

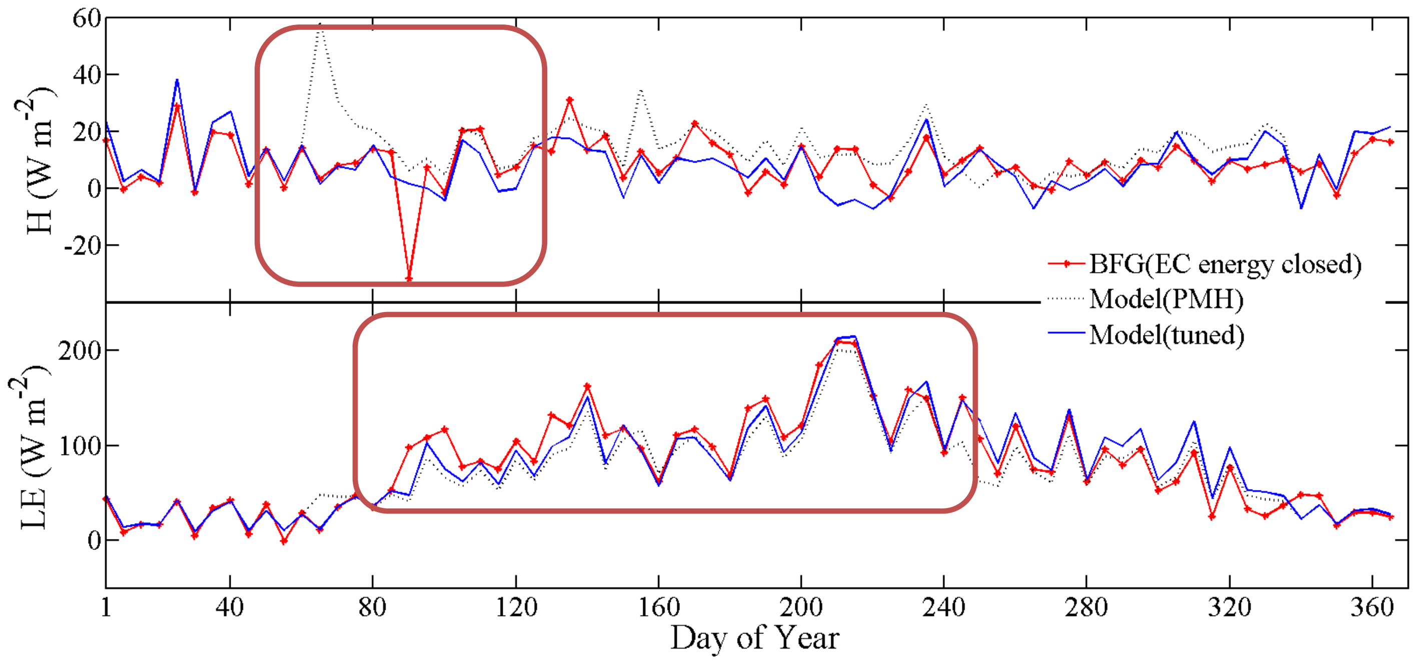


Fig.4. Time series of sensible heat flux (H, above), latent heat (LE, down), comparison of EC flux (red solid line), untuned modeled flux (gray dotted line) and tuned model flux (blue solid line),all the results are averaged in 5 days period.

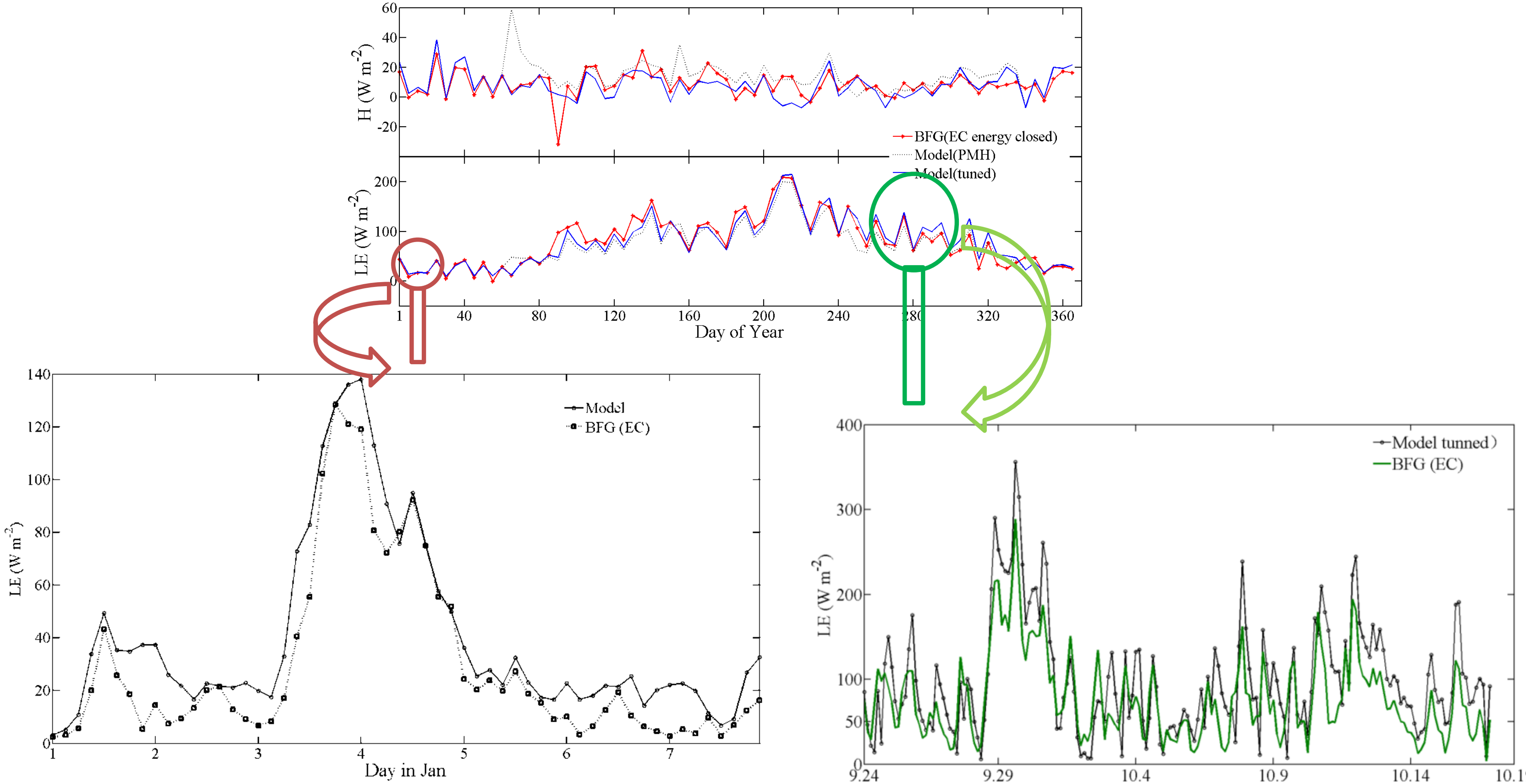


Fig.4. The part circled in brown (left) is from Jan 1 to Jan 7, the other part circled in green (right) is from Sep 24 to Oct 17. It's obvious that this model can capture the diurnal variation of LE.

Table 1

Comparison of untuned and tuned model with mean bias, RMSE and I are presented to show the improvement of tuned model.

	Piao			Tuned		
	Mean (model-obs)	RMSE	I	Mean (model-obs)	RMSE	I
H($W\ m^{-2}$)	5.46	10.76	0.65	-0.6	7.3	0.8
LE($W m^{-2}$)	-8.22	19.06	0.956	-0.7	14.8	0.98

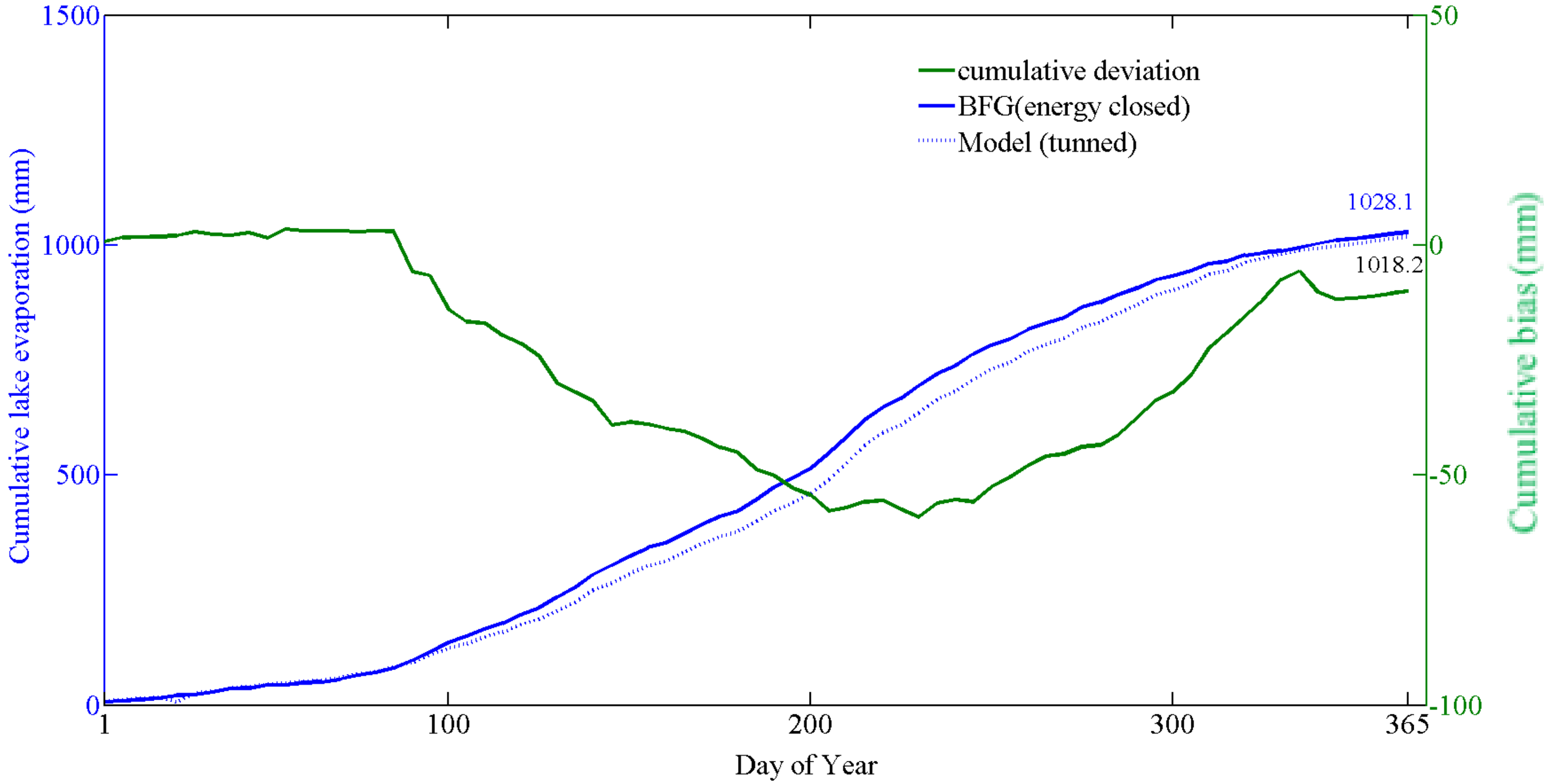
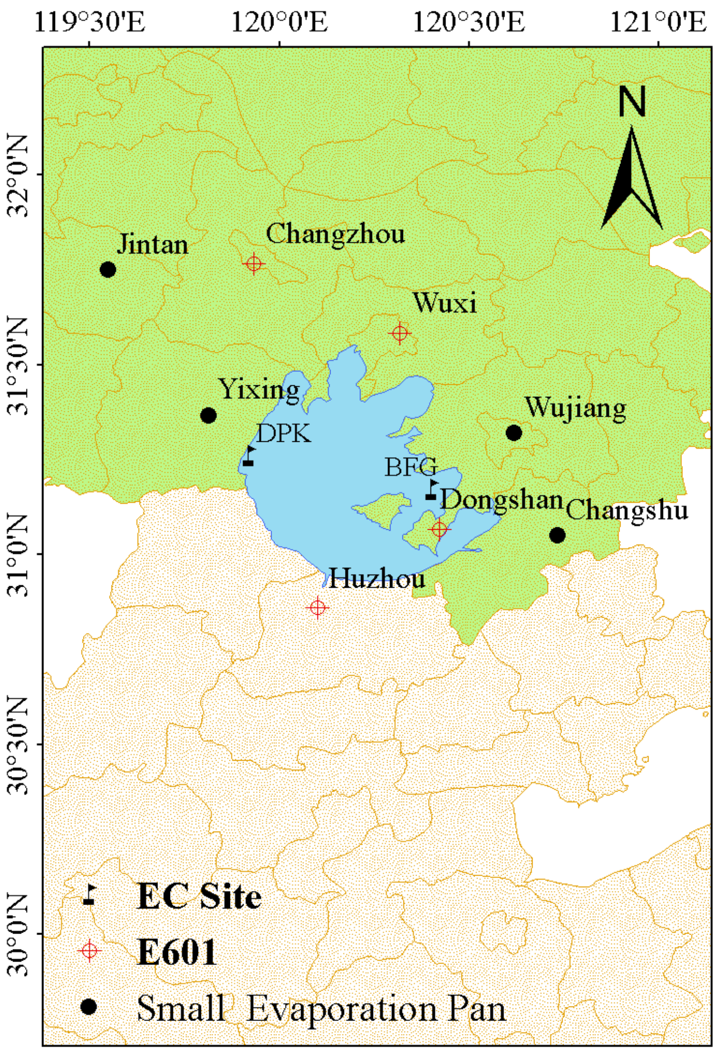


Fig.5. Left axis represents cumulative lake evaporation of EC (observation forcing energy closure, blue solid line), modeled (Tuned, blue dotted line), right axis represents cumulative bias.



Small Evaporation Pan:

E601 pan:

Fig.6. Map showing 4 small evaporation pan stations (black solid circle), 4 E601 pan stations (red cross circle) and 2 EC sites (Dapukou, DPK; Bifenggang, BFG).

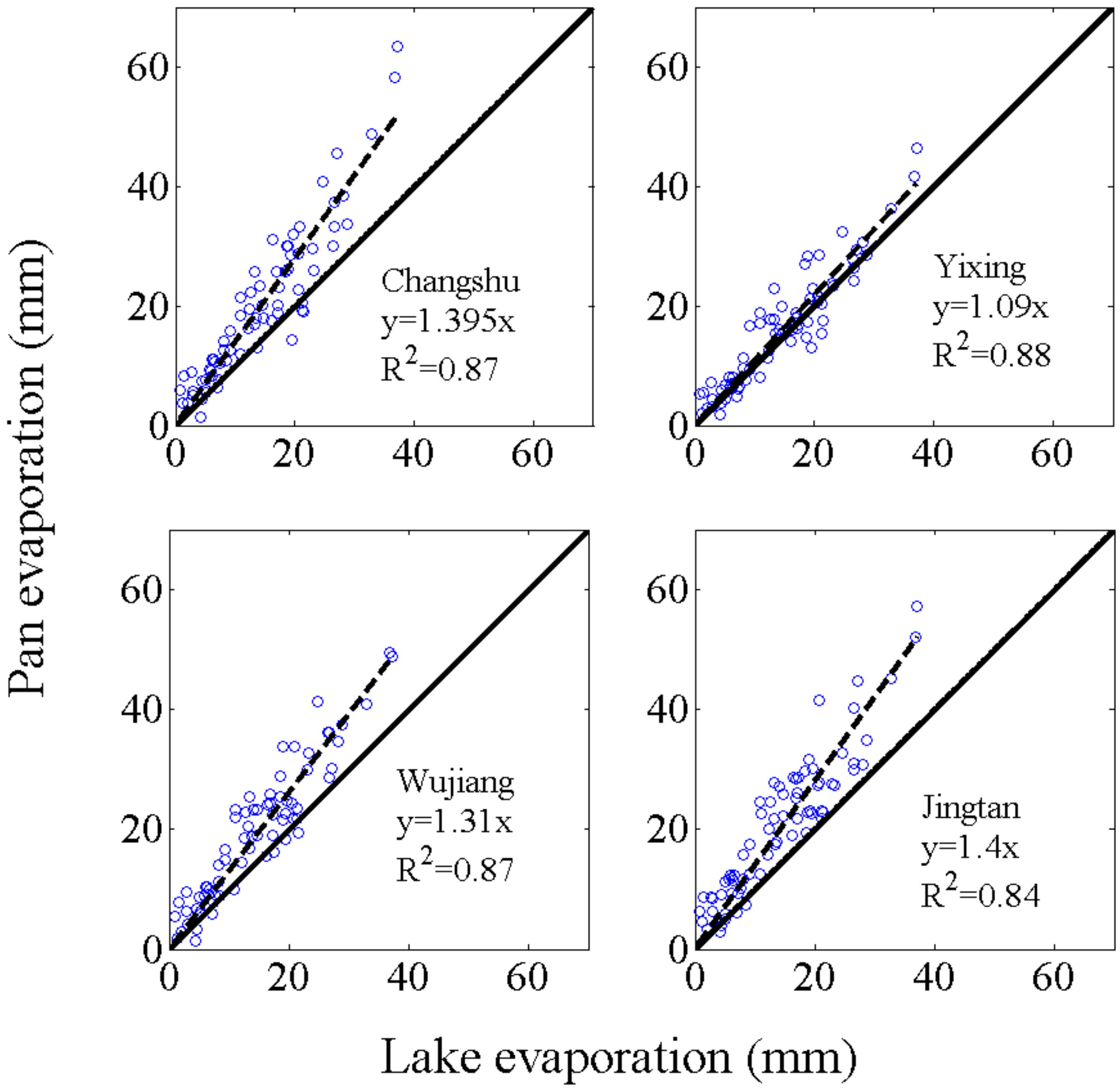


Fig.6. Comparison between lake evaporation and pan evaporation of 4 small pan stations.

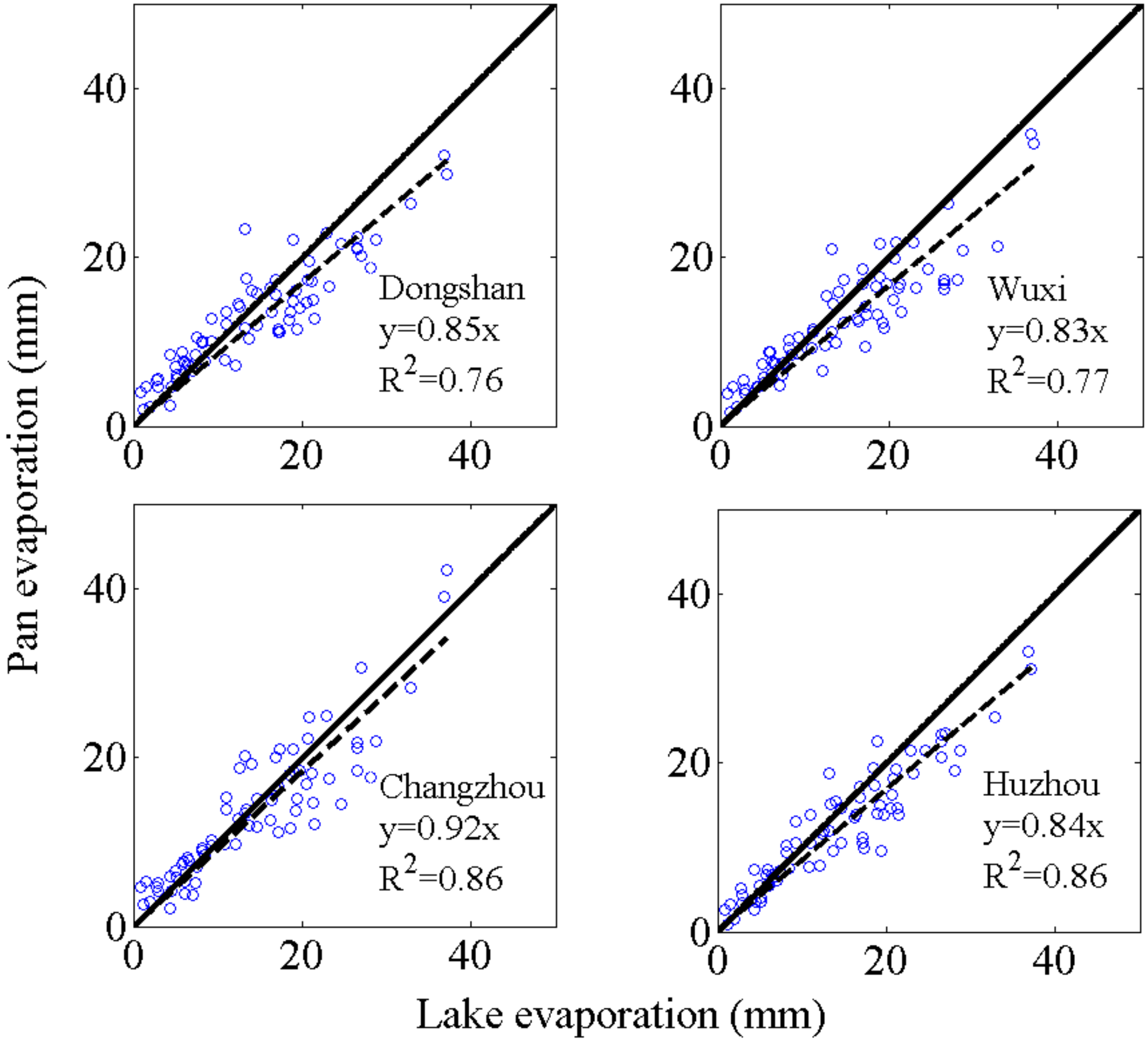


Fig.7. Comparison between lake evaporation and pan evaporation of 4 E601 stations.

Conclusion

- The tuned lake model has the ability to model diurnal variation of sensible and latent heat flux.

- The tuned model can be used to reappear the historical trend of evaporation in Taihu at year time scale.

- Because of the difference of 2 evaporation pans in structure and location, small pan evaporate more while E601 less compared with lake evaporation. But they show High correlation with lake evaporation, which can be used as indicator to rebuild the historical trend of evaporation in Taihu .

Thank you