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Offline test of the CLM-VRLS lake model at Lake Taihu

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1. Introduction

(1) Significance of lakes in weather and climate system:

- Heat buffer effect (e.g., cooling in Spring/Summer and warming in Fall/Winter)
- Lake-precipitation effect
- Important role in global carbon cycle

(2) Lake models in weather and climate simulations:

- Simulations covering lake areas rely on lake models for surface fluxes
- To date, no evaluation of model-predicted surface fluxes against direct flux observations has been performed

(3) Objectives of this study:

- Improve the CLM-VRLS lake model for flux predictions at Lake Taihu
- (next stage): Study lake-climate feedbacks at Lake Taihu and explore human impacts on these feedbacks

2. Site and model

(1) Lake Taihu, China (120.1°E, 30.2°N):

- Surface area: 2300 km^2; mean depth: 2 m
- Warm polymictic lake (no ice formation)

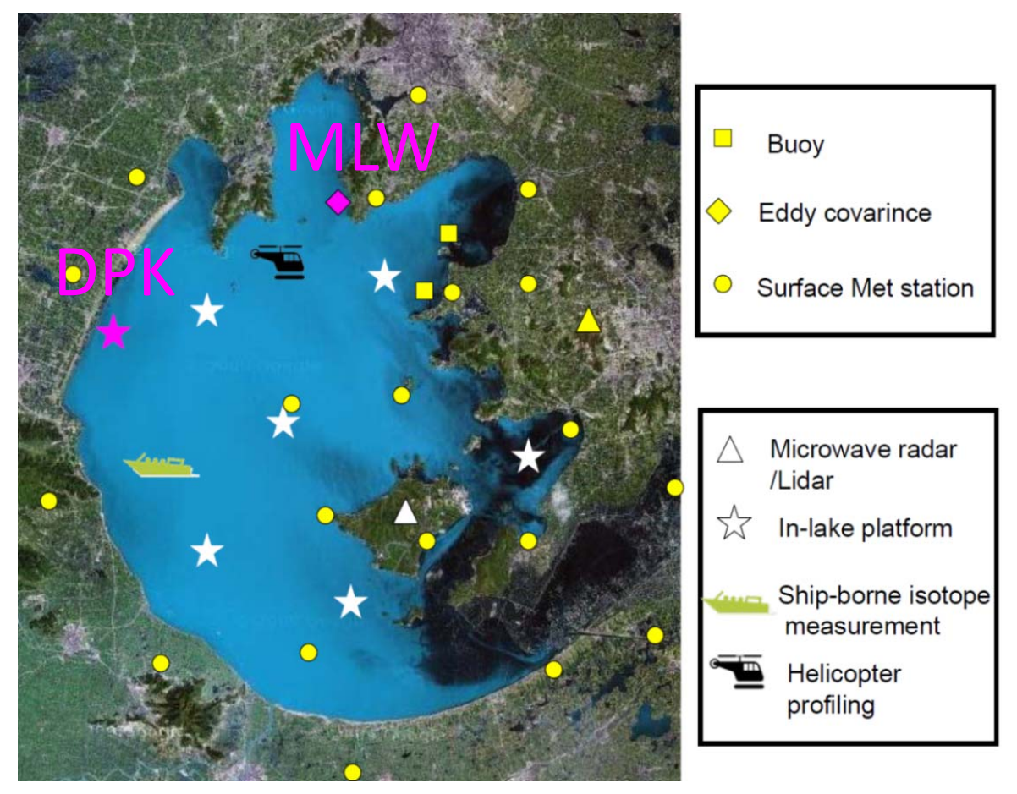

Fig 1: Lake Taihu Flux Mesonet

(2) Taihu Flux Mesonet (Fig 1):

- Eddy-covariance (EC) measurements available at different sites of the lake (Fig 2)
- Data from two sites were used, including the Mei Liang Wan (MLW) site and the Da Pu Kou (DPK) site (Fig 1)

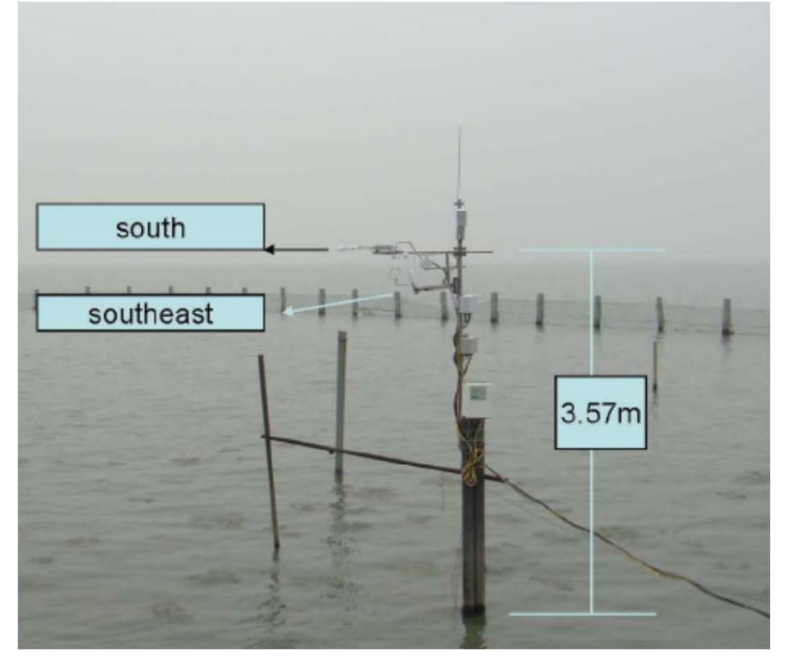

Fig 2: The EC system at MLW site

(3) Significance of Lake Taihu:

- Availability of in-situ flux observations
- Detectable climate trends in the Taihu Basin (Fig 3).
- Severe water pollution and rapid urban expansion (Fig 4)
- An ideal system for studying human impacts on lake-climate feedbacks

(4) The CLM-VRLS (vertically resolved lake simulator) lake model:

- An improved version of the CLM4.0 lake model developed by NCAR and LBNL scientists
- An vertically resolved lake simulator consisting of a surface module, a lake module and a hydrology module

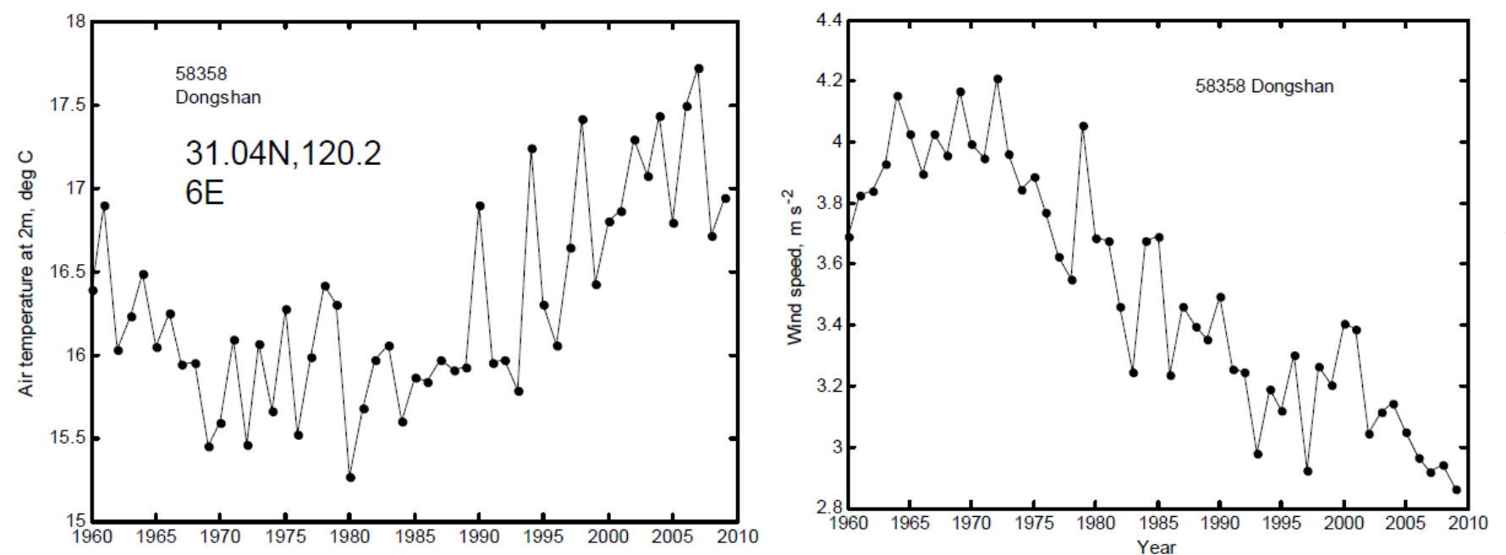

Fig 3: Climate trends in the Taihu basin

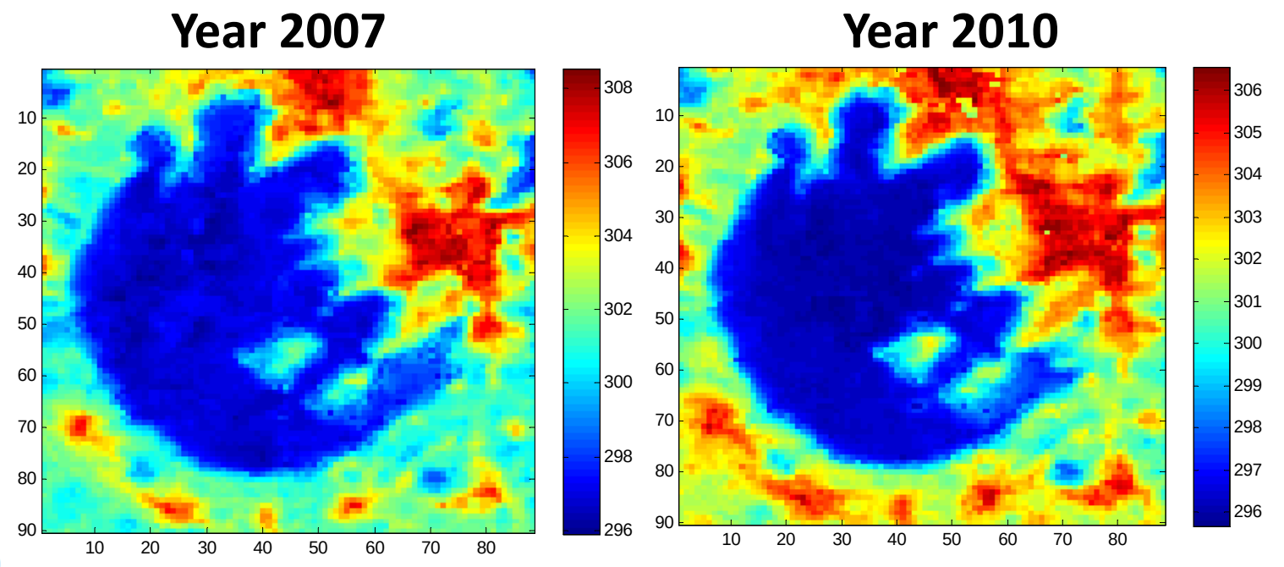

Fig 4: MODIS land surface temperature over June-August

3. Results

Two types of simulations were performed (Table 1):

- Simulations based on CLM-VRLS default parameters (**default run**)
- Simulations based on parameters specific to Lake Taihu (**tuned run**)

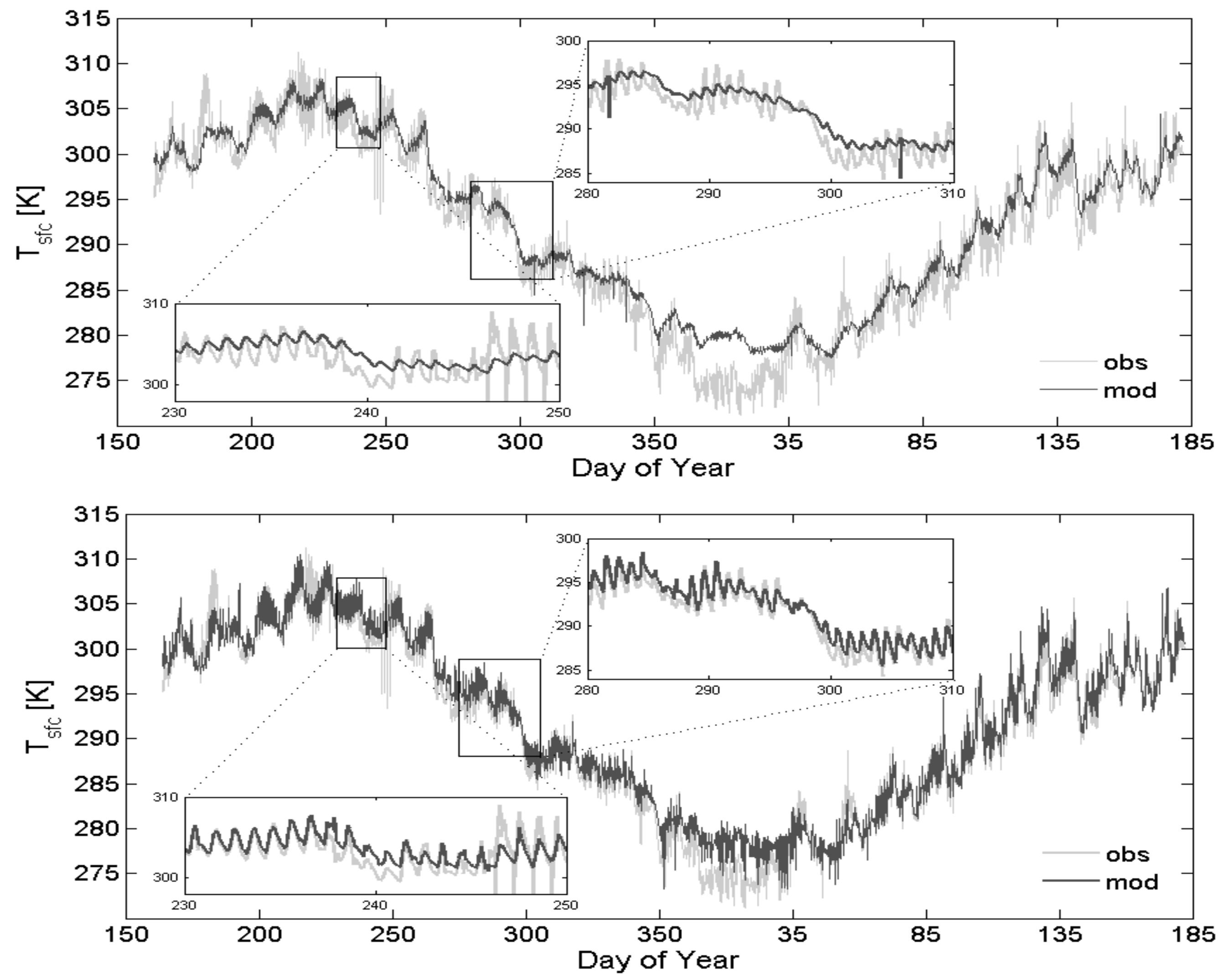

Fig 5: Simulation of T_{sfc} from DOY 164, 2010 to DOY 183, 2011. (top): default run; (bottom): tuned run;

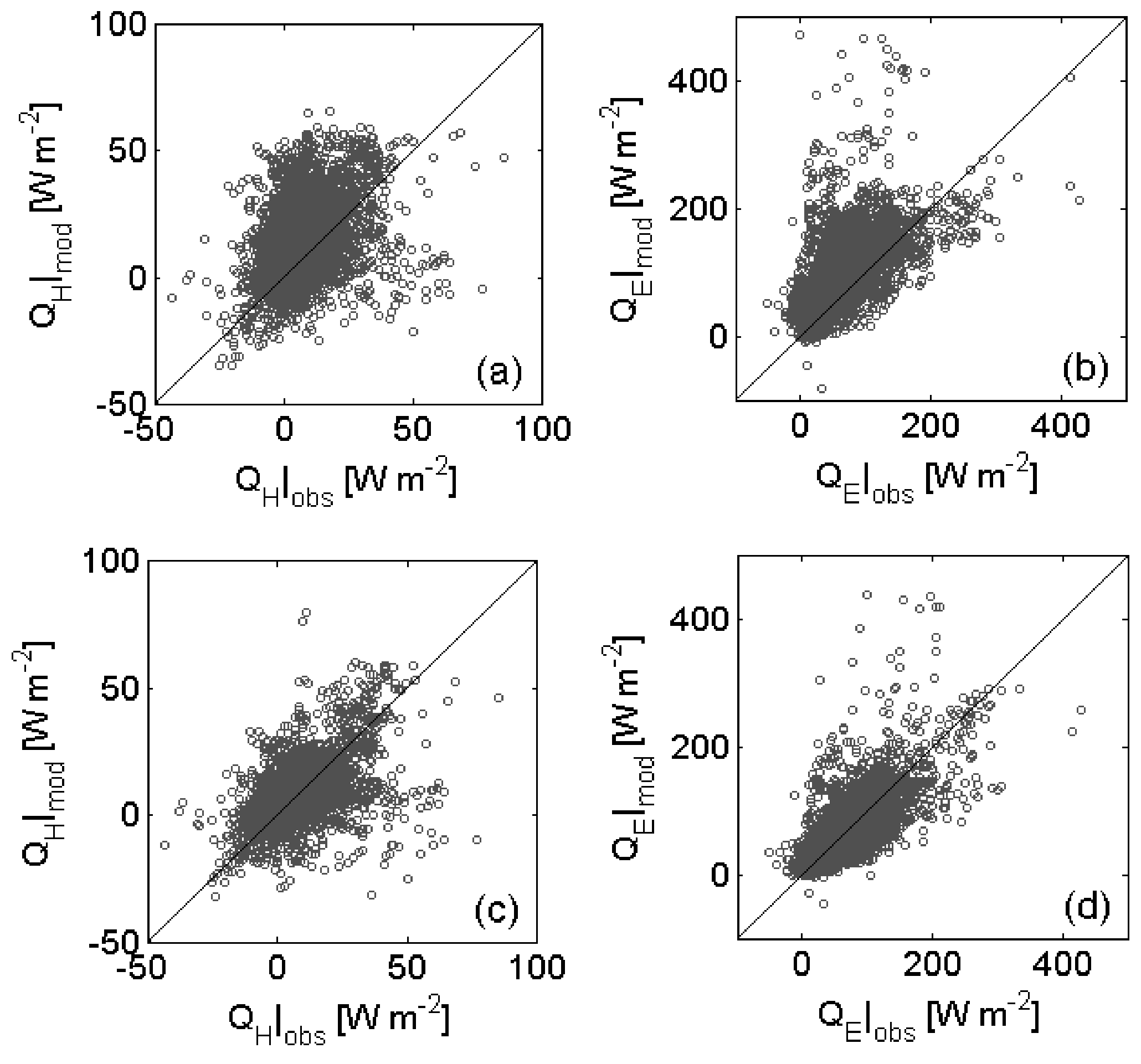

Fig 7: Comparing CLM-VRLS predicted Q_H and Q_E against observations at the MLW site. (top): default run; (bottom): tuned run;

Table 1: Model parameters

	Tuned version	CLM-VRLS default
Roughness lengths	z_{0m}= 3.3x10^{-4} m z_{0h} = 1.9x10^{-6} m z_{0q} = 3.9x10^{-8} m	Variables dependent upon wind speed, fetch and water depth
Light extinction coefficient (η)	5.0 m^{-1} (from literature)	0.89 m^{-1}
Eddy diffusivity (k_e)	2% of the CLM-VRLS value (Fig 6)	Wind driven; accounting for unresolved 3D circulation

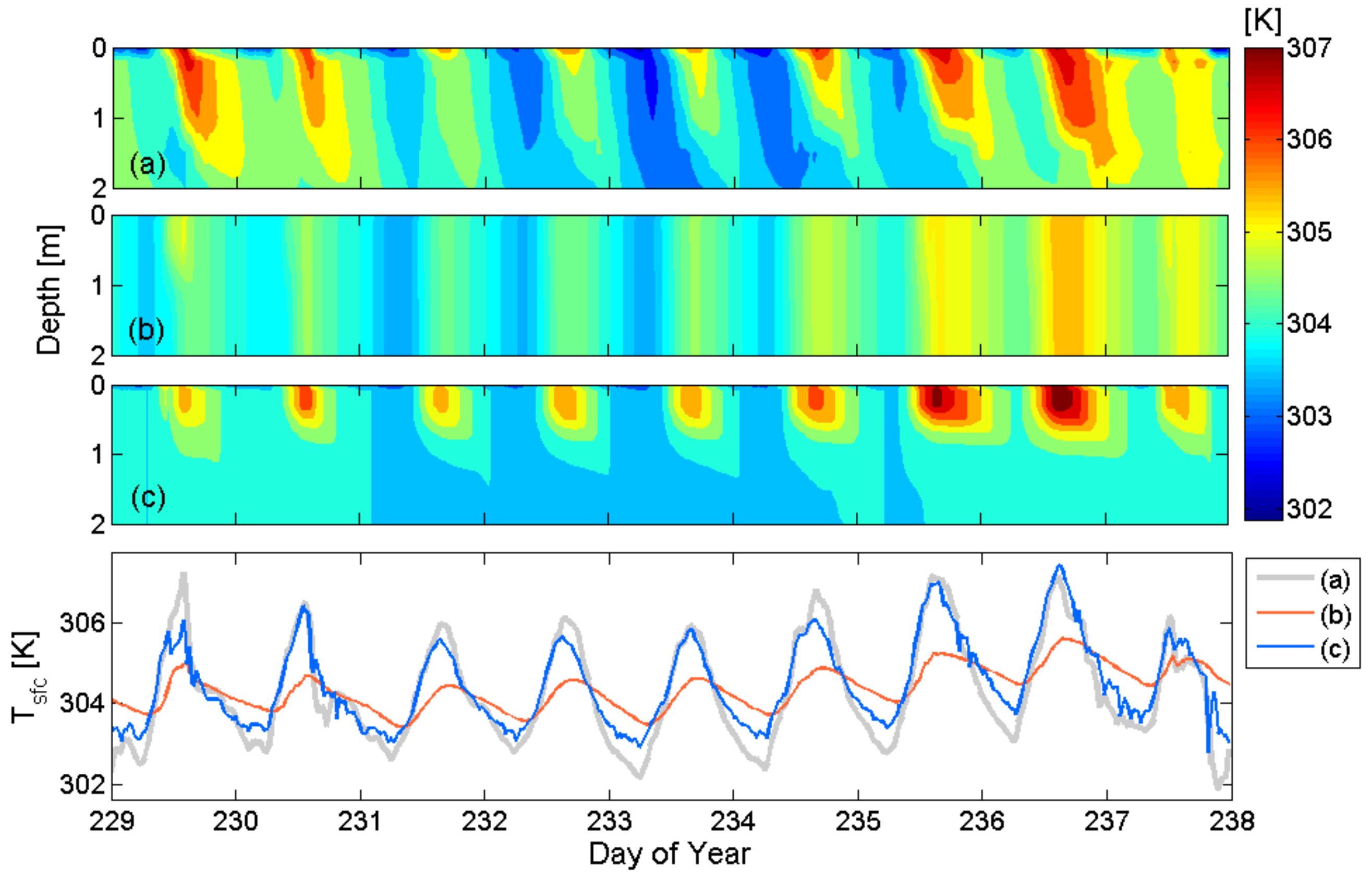

Fig 6: Lake water temperature from (a) observations; (b) default run (default k_e); (c) tuned run (2% of default k_e); (bottom) corresponding T_{sfc}.

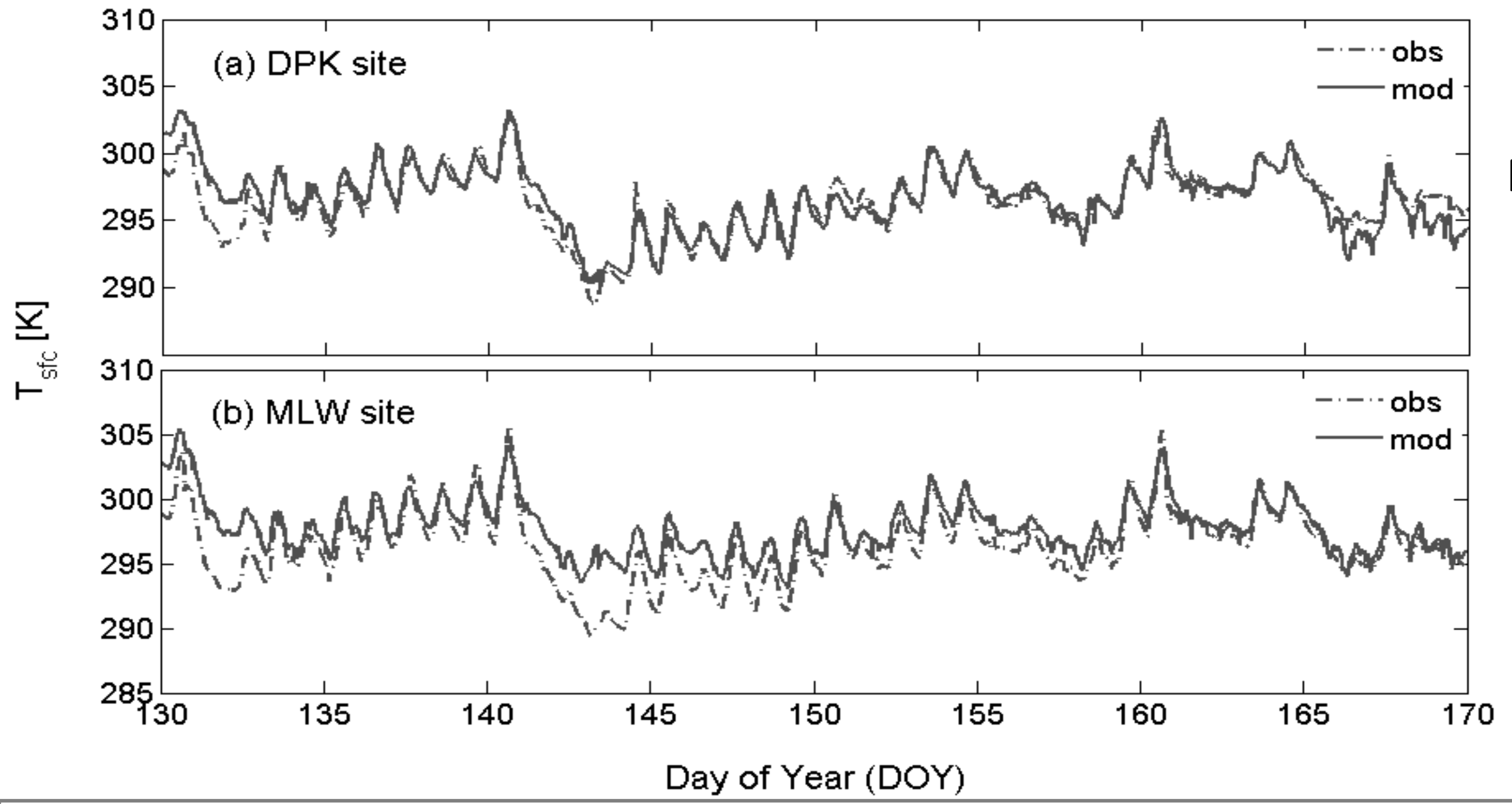

Fig 8: Predicted T_{sfc} from tuned runs against observations at the two EC sites (DOY 130 to 170, 2011)

4. Conclusions

- CLM-VRLS performs better at seasonal timescale than diurnal timescale
- Adoption of site-specific parameters significantly improves the performance of CLM-VRLS in flux predictions
- Vertical mixing seems much less efficient at Lake Taihu compared to deep lakes, probably because of the shallowness of the lake