We thank the reviewer very much for the valuable comments on our manuscript. The comments (bolded) are addressed below.

First, thank you for sharing your work. This is a very interesting study! You present a method of improving the thermal mixing of lakes in the Community Land Model (CLM). The new method introduced into CLM is K profile parameterization (CLM-KPP), a method utilized in ocean modeling. The current CLM vertical mixing scheme (CLMORG) assumes wind is the primary forcing in thermal mixing of lakes. KPP uses wind and surface thermal forcing to simulate lake temperatures. The model did not improve until a mixing event occurred on 16-31 August. CLM-ORG predicted a continued stratification of lake temperature from 16-31 August. CLM-KPP correctly estimated when and the magnitude at which the thermal mixing event would occur from 16-31 August. You provide a thorough analysis as to how thermal forcing within CLM-KPP was able to correctly predict that the mixing would occur. However, I believe there a couple of points that would enhance this work.

Major Comments 1. The study seems limited using only one lake and a very narrow time frame. I would recommend the inclusion of several study locations and/or a longer period of analysis to get a better sense of the implications of using CLM-KPP over CLM-ORG. Right now the impact of the study feels limited given that only one location is examined for a two month period during the same season.

Response: We chose another lake, Nam Co, located in the Tibetan Plateau (TP) to evaluate CLM-ORG and CLM-KPP. We conducted simulations at a 10-km spatial resolution for this lake over the period of 2003 through 2012. Our simulations showed that the lake water surface temperature simulations with CLM-KPP were significantly improved when compared with observations and CLM-ORG simulations. We have added simulations and analysis for Nam Co to the manuscript:

"We validated both CLM-ORG and CLM-KPP with the monthly Moderate Resolution Imaging Spectroradiometer (MODIS) data for Nam Co by conducting 10-km spatial resolution simulations for this lake over the period of 2003 through 2012. We can see that CLM-KPP improved WST simulations averaged over the entire lake (34 model grid cells) when compared with the MODIS data and CLM-ORG simulations (Fig. R1). The RMSE of WST decreased from 4.58 ˚C with CLM-ORG to 2.23 ˚C with CLM-KPP, and the R increased from 0.90 to 0.96 at the same time.

The improved WST simulations with CLM-KPP were closely related to the water mixing simulations with the KPP as discussed in the manuscript. We averaged the K_w^{ORG} and K_w^{KPP} simulations over the water columns with the depth greater than 25 m for Nam Co as shown in Fig. R2, and the total of such columns were 28 out of 34 for this lake. Figure R2 indicated that K_w^{KPP} was slightly smaller than K_w^{ORG} mostly in the mixing layer of the lake over the summer. The difference likely resulted from the enlarged K_w^{ORG} in CLM where this parameter was increased by a factor of 10 when the lake depth was greater than 25 m. In the deeper part of the lake, K_w^{KPP} was much smaller than K_w^{ORG} over the summer due much to

K_{ed}'s contribution to K_w^{ORG}. In the spring and fall seasons, K_w^{KPP} was significantly larger than K_w^{ORG} where the buoyancy flux may contribute strongly to K_w^{KPP}. During the winter time when the lake froze, both CLM-KPP and CLM-ORG were set to use K_w^{ORG}. We can see that the most significant improvements in WST for Nam Co occurred during the ice-free seasons when the KPP was activated. Thus, the thermal forcing was an important factor in simulating lake mixing, which needs to be considered in lake models."

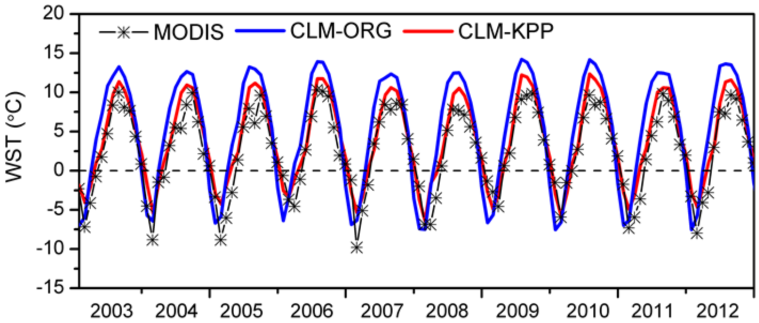

Figure R1. The time series over the period of 2003 through 2012 of monthly WST observations from MODIS (black star line) and simulations with CLM-ORG (blue line) and CLM-KPP (red line) (Unit: ˚C).

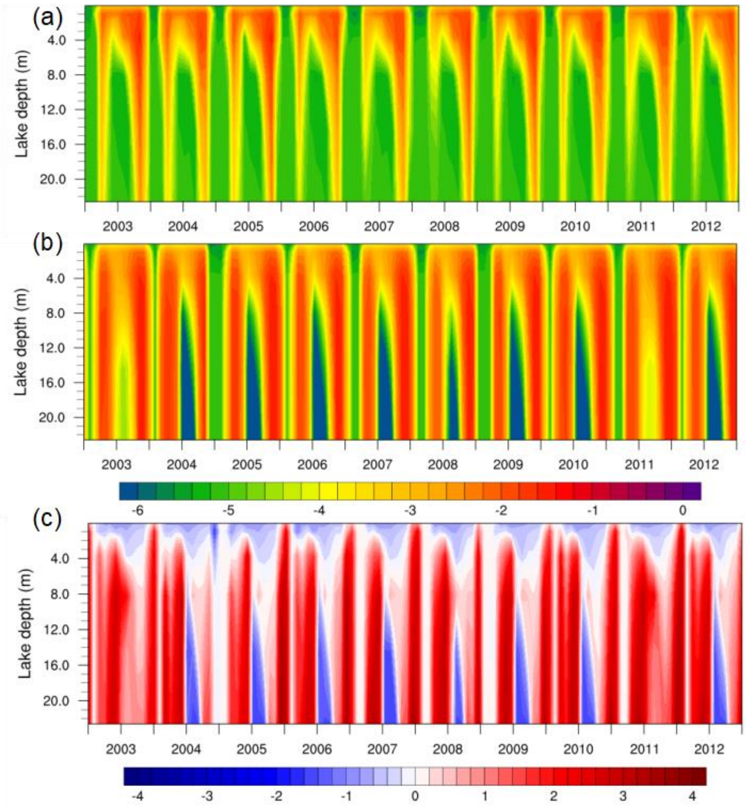

Figure R2. The simulated (a) $\log_{10}\mathrm{K}_\mathrm{w}^\mathrm{ORG}$ with CLM-ORG, (b) $\log_{10}\mathrm{K}_\mathrm{w}^\mathrm{KPP}$ with CLM-KPP (Unit: m^2/s) averaged over the water columns with the depth greater than 25 m (28 of 34 grid cells), and (c) the differences between $\log_{10}\mathrm{K}_\mathrm{w}^\mathrm{KPP}$ and $\log_{10}\mathrm{K}_\mathrm{w}^\mathrm{ORG}$ ($\log_{10}\mathrm{K}_\mathrm{w}^\mathrm{KPP} - \log_{10}\mathrm{K}_\mathrm{w}^\mathrm{ORG}$).

2. Related to 1, you do not provide an analysis of how the stratification beginning on 16 Aug better informs ecosystem,

meteorological, or climatological analysis for the lake. A better discussion of implications of capturing this mixing, particularly if any were observed, would enhance this work.

Response: Stratification plays an important role in lake production and food webs. Stratification and warmer epilimnion temperatures create conditions necessary for phytoplankton production. Also, when arctic lakes become strongly stratified, the hypolimnion can become anoxic, which in turn, increases nutrient recycling and leads to elevated production the following spring (O'Brien et al., 2005). Increased food availability and warmer lake temperatures in the epilimnion from stratification increase arctic char growth. Finally, simulations of stratification date and epilimnion temperature are used in bioenergetic models to estimate fish growth and consumption and better understand arctic char production with global environmental change (Budy and Luecke, 2014).

3. Line 169-180: You discuss how RMSE and correlation (R) improved with CLM-KPP only slightly for the entire simulation period. I suggest that since you use these metrics, divide the calculation of these metrics into a before and after the mixing event occurs. This would strengthen your point. You should then note this in the abstract and conclusions to better illustrate the impact that CLM-KPP has in the simulation.

Response: Based on this comment, we separated our entire simulation period for Fog3 Lake into the before and after mixing periods and calculated RMSEs and Rs for these two periods as well as the entire simulation period (Table R1). We can see that CLM-KPP remarkably improved the water mixing simulations in Fog3 Lake when compared with CLM-ORG.

Table R1. RMSEs (˚C) and Rs of the temperature profile simulations with CLM-ORG and CLM-KPP for Fog3 Lake for the three periods of 1 July through 15 August, 16–31 August, and 1 July through 31 August in 2018.

	1 July–15 August, 2018		16–31 August, 2018		1 July–31 August, 2018	
	RMSE (˚C)	R	RMSE (˚C)	R	RMSE (˚C)	R
CLM-ORG	1.1	0.93	1.4	0.57	1.2	0.90
CLM-KPP	1.3	0.92	0.3	0.99	1.0	0.95

Minor comments

Line 100: Please define phi.

Response: Actually, we define phi (φ) in Line 99 "k^* is related to latitude φ" in the manuscript.

Line 161: How did you decided upon the 24 layers you specify?

Response: Observed lake temperatures for Fog3 Lake are for the lake depths of 0, 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, and 16 m. CLM-ORG has 10 lake layers by default, and the center point depths of these layers are 0.05, 0.3, 0.9, 1.9, 3.3, 5.1, 7.5, 10.3, 13.79, and 17.94 m generated automatically by the layering scheme in the model based on the input lake depth. For this study, we tried to keep each layer thin in the top part of the lake to reflect diurnal cycles (layers 1-5) in both CLM-ORG and CLM-KPP. Below layer 5, mostly we used the observed points to layer the rest of the lake column. Finally, we produced 24 layers for the entire lake column in both models, and the center point depths of these lake layers are 0.05, 0.15, 0.25, 0.35, 0.45, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19.25 m, respectively. As shown in the Fig. R3 and Table R2, the simulations of CLM-ORG with both 10 and 24 layers were very similar, while the simulations of CLM-KPP with 24 layers were closer to observations than those with 10 layers when the water mixing event occurred. These results indicated that a high resolution layering in CLM-KPP may be important for simulating lake water mixing.

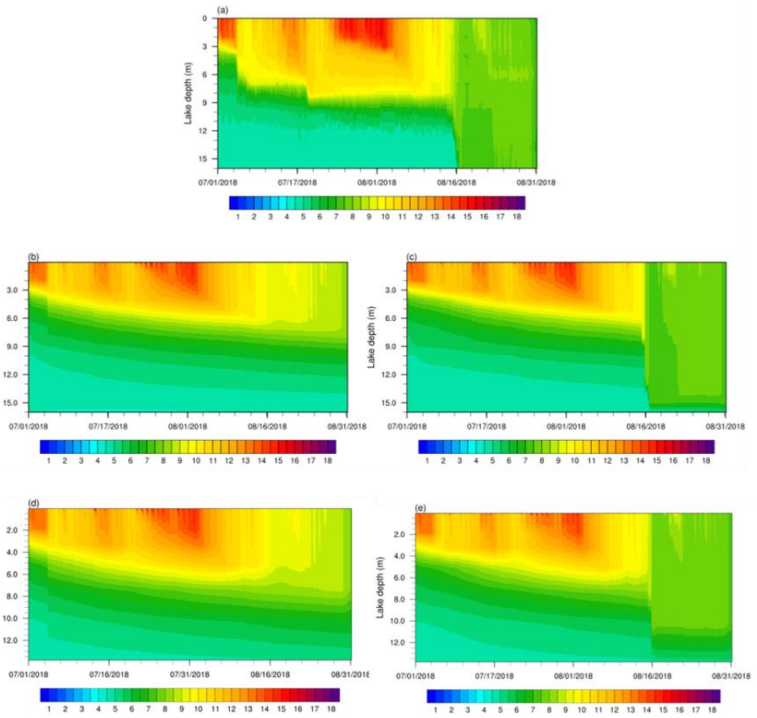

Figure R3. Lake temperature profiles of (a) observations, simulations of (b) CLM-ORG and (c) CLM-KPP with 24 layers and simulations of (d) CLM-ORG and (e) CLM-KPP with 10 layers (unit: ˚C).

Table R2. RMSEs (˚C) and Rs of the temperature profile simulations of CLM-ORG and CLM-KPP with 10 and 24 layers for Fog3 Lake over the three periods of 1 July through 15 August, 16–31 August, and 1 July through 31 August in 2018.

		1 July–15 August, 2018		16–31 August, 2018		1 July–31 August, 2018	
		RMSE (˚C)	R	RMSE (˚C)	R	RMSE (˚C)	R
10 model layers	CLM-ORG	1.0	0.94	1.4	0.58	1.1	0.92
	CLM-KPP	1.2	0.94	0.7	0.90	1.1	0.94
24 model layers	CLM-ORG	1.1	0.93	1.4	0.57	1.2	0.90
	CLM-KPP	1.3	0.92	0.3	0.99	1.0	0.95

References

Budy, P., Luecke, C.: Understanding how lake populations of arctic char are structured and function with special consideration of the potential effects of climate change: a multi-faceted approach, Oecologia, 176(1), 81-94, https://dx.doi.org/10.1007/s00442-014-2993-8, 2014.

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