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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Improving lake mixing process simulations in the Community Land Model by using K profile parameterization" *by* Qunhui Zhang et al.

Anonymous Referee #1

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The manuscript presents results of introducing "K profile" parameterizatioin of turbulence into lake module of Community Land Model. This is likely the first time K profile parameterization is used in a 1D lake model, though it is widely applied in ocean models. Incorporation of new turbulence closure instead of standard Henderson-Seller diffusivity lead to significant improvement of simulation of late-summer destratification event in an Alaskan lake.

General comment

My general comment on the manuscript is that since single mixing event is simulated, more physical analysis could be provided to explain *why* K profile closure performed

better than Henderson-Sellers in this case. Analysis presented in sections 3.1 and 3.2 is superficial and does not touch this question. One mixing case is not enough to state that K profile is better in similar situations in general, so more substantial inquiry into physics behind both parameterizations is needed. The authors state that KPP includes effects of thermal forcing, whereas original scheme of CLM model does not. This is actually not correct. First, original CLM model includes convective adjustment scheme (Subin et al., 2012) which instantaneously mixes the unstably stratified water column. Then , the effects of stable stratification are included via Brunt-Vaisala frequency in Henderson-Sellers (H-S) diffusivity. Thus, thermal (density) stratification is taken into account. The mixing event the authors focus on happens during weakly stable stratification under strong wind forcing. One may conclude from simulation results presented is that given the same stable temperature profile the larger wind speed is needed for H-S to mix completely the water column than for KPP model. This may be elaborated by conducting idealized simulations with both turbulence closures with varying wind speeds and temperature profiles where this statement may be checked and respective quantitative estimates provided.

Specific comments

1) Lines 88-90: "Researchers have attempted to advance this lake model to more closely reflect reality over the last two decades (Fang and Stefan, 1996; Henderson-Sellers, 1985; Hostetler and Bartlein, 1990; Subin et al., 2012)." Three of four papers cited here do not deal with CLM model.

2) Lines 92-93: "... is the enhanced eddy diffusivity for unresolved mixing processes". All mixing processes in 1D model are unresolved and are parameterized, because only 3D model of sufficiently high resolution simulates turbulence explicitly.

3) Line 98: "0.0012 u_2" I guess, you can write drag coefficient C_d instead of 0.0012, to make the physical sense of this equality clear.

4) Eq. (5): please separate this fraction into two.

5) Section 2.1.1: you didn't mention convective adjustment scheme in CLM lake model. It should work during nights in your simulation.

6) Section 2.2: too concise description of the lake. Put more info on climate and landscape conditions, hydrological regime, previous research of the lake.

7) Line 154: "wind-only driven scheme". Again (see above), it is incorrect to state that basic CLM lake model includes only wind forcing, as it accounts for both stable and unstable stratification.

8) Section 2.3: I would add more info on the organization of measurements. Is there a mast on a lake? Which organization runs measurements? Any relevant references?

9) Line 173: "estimates a stratified lake" : sounds badly, please rephrase.

10) Table 1 is too small, you can easily present those numbers directly in text.

11) Lines 183-184: "Thermal forcing played a vital role in this enlarged diffusivity, which was considered only in CLM-KPP and not in CLM-ORG." See my comment 7 above and general comment.

12) Line 188: "10^{-7}" please put units and elsewhere in the document.

13) Line 188: "was the product" It is not product, but a sum.

14) Lines 198-201: two sentences, stating almost the same.

15) Line 238: "absorbed solar radiation". It is radiation flux.

16) Lines 239-240: "total eddy diffusivity". Better: total diffusivity.

17) Eq. (A3): a0, a1, ... Better to put numbers into subscript (a_0, a_1, ...).

18) Eq. (A4) (both equations): there is a derivative sign in numerator and not in denominator.

19) Line 244: Not clear, what is $v(h)$? You say, it is "water diffusivity". But, water

diffusivity is K_w. There are also molecular diffusivity, background diffusivity, diffusivity caused by internal waves . . . all denoted differently above.

20) Line 246: replace "buoyancy difference" by "buoyancy".

References

Subin Z.M., Riley W.J., Mironov D. An improved lake model for climate simulations: Model structure, evaluation, and sensitivity analyses in CESM1 // J. Adv. Model. Earth Syst. 2012. Vol. 4. No. 1. p. M02001.

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