

Reviewer comments to Satellite-Derived Light Extinction Coefficient and its Impact on Thermal Structure Simulations in a 1-D Lake Model by Zolfaghari et al. 2016

The authors have significantly improved the manuscript and replied adequately to most of the reviewers' comments. The manuscript is now structurally sound and easy to follow. There are still several things that need clarifying and corrections, but these can be considered as minor comments.

General comments:

Abstract is long and occasionally overly detailed. It should be more compact. Acronyms should be used only when necessary. Now there are e.g. MBE and I_a , which are not commonly known. Since the abstract should be shortened, I suggest to leave out these statistical parameters.

Sometimes present tense is used in the manuscript even though past tense is more appropriate.

Specific comments:

Page 1, lines 11-12. "...algorithm is applied to MERIS satellite imagery to estimate K_d and evaluated against K_d derived from Secchi disk depth...". As written, it is not clear if the algorithm is evaluated against K_d from SDD or is it the estimated K_d that is evaluated against K_d from SDD. I suggest to change it to: "... to estimate K_d , which was evaluated against...". I'm not a native English speaker but think that more attention should be paid on sentence structure throughout the manuscript.

Page 1, line 24-25. "Dark waters always produce warmer MWCT". Should it read 'colder MWCT'? At least Fig. 6b implies so.

Page 2, line 8. "Lake Surface Water Temperature...", only the first word should have capital initial letter.

Page 2, the second paragraph is really long and could be separated into two paragraphs. The second paragraph could start e.g. after "...derived from satellite imagery." in line 28.

Page 2, line 27. The reference Heiskanen et al., 2015 can be omitted because it is clear from the sentence that the authors refer to this study.

Page 2, lines 32-33. "The daily mean LSWT range increased...". It is not clear what is meant with the word 'range' because only one number (not range) is given for clear and dark waters.

Page 3, line 19. "... to investigate the improvement...". If this is the first study to use satellite-derived K_d in FLake simulations, how can it be known from beforehand that the model performance is improved? Maybe the word 'improvement' could just be omitted: "... to investigate the model performance..."

Page 3, line 20. "... and a constant value...". Be more specific, a constant value throughout the study period, or constant value of 0.2 m^{-1} or some other type of constant value.

Page 3, line 20. I suggest to change the word 'demonstrate' to 'evaluate' for pretty much the same reason as in the comment about 'improvement'.

Page 3, line 23. "... to K_d values based on simulated LSWT,...". Sentence structure should be changed because now it reads that the K_d values are based on simulated LSWT etc.

Chapter 2.1. There are now many references to Fig. 1 (page 4, lines 3-4, 10-11, 13, 23) even though only one would be needed. I suggest to put a sentence in the beginning of the paragraph starting "The meteorological forcing..." that says e.g. "The data for this study was collected from different stations shown in Fig. 1.". Then delete the other references to Fig. 1.

Page 4, line 4. Remove the coordinates and depth from here or from page 6, line 21.

Page 4, line 6. "Water temperature is also measured at 0.6 m below the water line.". It seems to me that water temperature is measured only at 0.6 m depth, and therefore the word 'also' should be deleted. I also suggest to use 'water surface' instead of 'water line'.

Page 4, line 32. Does the "(see Fig. 1)" refer to the corresponding tile or only to the station? If only to the station, then this ref. can be omitted. If it refers to the tile, that should be specified in Fig. 1. Now there are vertical dashed lines in the figure but they are not defined in the caption.

Page 5, line 10. At least to me it is unclear what the term 'screen height' means. If this is generally known definition, then okay, but if not, it should be specified.

Page 5, line 12. "NWRI-EC", change to "NWRI" so that same terms would be used throughout the manuscript.

Page 5, line 18. "... Earth's surface high spectral...". Is there a word missing between 'surface' and 'high'?

Page 5, line 23. The "in Lake Erie (see Fig. 1)" could be omitted, it has already been defined where the station is.

Page 5, line 25. The authors use different terms to mean the same thing, e.g. "CC Level2W", "CC MERIS L2W", "CC L2W". Make sure that the same term is always used. It is also not clear what Level2 data product means.

Page 5, line 26. "concentration of water constituents". This surely doesn't mean ALL the constituents, so it should be changed to "concentration of some water constituents" or similar.

Page 6, line 18. Are all these references really needed for this statement?

Page 7, line 1. I suppose that it should read that the MBE is calculated as the *mean of* modelled values...

Page 7, line 12. Could the authors provide a reference for the statement that resuspension is the most important cause for low water clarity in Lake Erie? Later, heavy plankton blooms are also discussed as the cause of high differences in water clarity.

Page 7, equation 2. It has been shown in later studies that the relationship between K_d and SDD is not constant, as the authors also discuss later in this chapter. It is unclear why the authors want to argue here that it is constant. Or has this relationship been the basis of relating CC-derived K_d and SDD together? If so, why that was used instead of the exponential relationship shown e.g. in Arst et al. 2008?

Page 8, lines 15-17. The authors say that, after SDD validation, the satellite-derived water clarity (as such, without any modifications) was used in the modelling. There seems to be quite good agreement between SDD and CC-derived K_d when $SDD > 3m$ (Fig. 3). However, in Discussion the authors state that in situ measurements of water clarity are a requirement for satellite-derived K_d . Is there some reason to assume that in (clear) waters in general (e.g. $SDD > 3m$) the satellite imagery doesn't provide reasonably reliable estimates of K_d ? In other words, if it worked for Lake Erie, what are the assumptions that it might not work on other lakes?

Page 8, line 16. "are deemed to be correct". There is huge scatter in Fig. 3 when $SDD < 2m$, so it is an overstatement to say that the satellite-derived K_d are correct. I suggest to change the wording to "can be considered representative".

Page 8, lines 21-22. Very complex and vague subordinate clause (motivating the investigation of potential of integrating). Be more specific.

Page 8, line 30. "focused on", change e.g. to "shown for"

Page 9, paragraphs 1 and 2. It is quite difficult to follow the big picture what was done. This could be made easier for the reader if e.g. after "..., respectively." on line 4, a new sentence would be written: "We made four different simulation schemes which were then compared to the observed LSWT".

Page 9, line 6-7. Where does the acronym CRCM come from?

Page 9, line 11. Change sentence order from "surface temperature in spring (April-June) is modelled warmer" to "surface temperature was modelled warmer in spring (April-June)"

Page 9, lines 11-13. Looking at Fig. 4, it seems to me that 2006 and 2007 'merged', 'avg', and 'obs' are quite similar from late-June to mid-August. This is contrasting to what is now written in the text.

Page 9, line 16. Change sentence order from "to more slowly gain (lose) heat" to "to gain (lose) heat more slowly".

Page 9, line 17. Change "The performance" to "The overall performance".

Page 9, paragraph starting with Fig. 5. and Fig. 5 itself. Write the text in the same order as they are presented in the figure. Either change the order in the text or in the figure. Now the discussion starts with CRCM simulations whereas they are panels c and d in the figure.

Page 9, line 29-30. This needs a bit of rephrasing because according to the figure the CRCM simulations underestimate the observed LSWT only when LSWT is roughly >7 deg C.

Page 10, line 29. The authors argue that solar radiation is absorbed more in dark waters due to existing particles in water. If you can reliably state that this is true for Lake Erie, then the explanation is acceptable. But even in this case I suggest to change 'dark waters' e.g. to 'waters with low clarity' because particles do not always make the water dark, and the water can be dark without particulate matter.

Page 10, line 30. "(lower LBWT...)". I suggest to change it to "(which shows in lower LBWT...)" so that the reader doesn't need to guess what the authors try to imply.

Page 10, line 30. Fig. 8 can not be introduced before Fig. 7 has been introduced. Either change the text or one option would also be to combine Fig. 8 to Fig. 6 (it could e.g. be subplot d in Fig. 6).

Page 11, line 26. "lessening of the radiative absorption" implies that something has happened in the lake. I suggest to change this to "decrease in radiative forcing" which means that the incoming radiation from the atmosphere has decreased.

Page 11, lines 28-29. These are very vague sentences and not all parts true. The deepening of the thermocline is related to wind forcing. In dark waters the density gradient is sharp and forms an effective barrier for the wind-induced mixing to reach deeper depths. In clear waters the density gradient is weaker and therefore mixing can more easily deepen the thermocline. There are many processes working at the same time in lakes that affect thermal stratification. Besides heat transfer, wind currents and internal waves are important. Because the same wind forcing is used as an input for all the different model runs, it is important to explain how water clarity takes part into the development and progress of thermocline.

Page 11, line 30. "derived from isotherm". Be more specific how MLD was defined. It seems to me that the authors have identified the MLD correctly, but there are many ways to do this and no general guideline how to do this. Therefore, more specification is needed.

Page 12, paragraph starting with "In the darkest water...". Here the same oversimplifications are presented. If there is no wind, there is no mixed layer in clear or dark water because there is only stratification, no mixing. So the explanation is not only that in clear waters the solar radiation can distribute to a larger volume in the water column. Very important factor is also how much (deep) of the density stratification can be destroyed by wind-induced turbulent kinetic energy. In dark waters this layer is shallower than in clear waters and therefore dark waters have shallower MLD with the same wind forcing.

Page 12, lines 9-25. If there is some study that shows that FLake predicts well the ice phenology in Lake Erie, then this text can be as it is and that study should be cited. Otherwise, these are only simulation runs without validation, and therefore in the beginning or in the end of these paragraphs a text should be added that mentions "It must be noted that these results couldn't be verified because of lack of measurements" or similar.

Chapter 3.3. This chapter needs the most modification. Now there are three main points in the chapter: 1. spatial variation, 2. temporal variation, and 3. inter-annual variation of K_d . Currently, the authors briefly describe what was observed and show the figures, but the meaning and importance of these findings are not elaborated. From the figures 10-12 it seems evident that these are important findings but these are not discussed. For example, it seems interesting that K_d can be time-independent constant even though there are huge changes in K_d both in space and in time. If K_d influences the thermal stratification as shown in Fig. 7 and related studies, then it would be reasonable to assume that the thermal stratification is very different in the western end of Lake Erie than in the eastern end. Yet, some studies and results suggest that one lake-specific but constant K_d can be used to model the stratification. Fig. 11 seems to imply that in big lakes lake-specific K_d cannot be used.

Page 13. K_d values are presented as average value plus minus some number. Could you specify what the number is.

Page 13, line 25. It seems that the years for CC product are 2003-2012 (fig. 2), not 2002-2012. When this paragraph is written as it is now, it seems that these were the years for all the measurements and modelling. In order to not be misleading, specify at least for which years the model runs were made.

Page 14, lines 8-9, first sentence of this paragraph. It is unclear what the authors mean with the concept of 'thermal regime of lakes' in regards of this study. Only observed surface water temperatures are used to validate modelled temperatures. All the rest (water column temperature, bottom water temperature, mixed layer depth) are only simulated and thus tells more of how FLake model performs with different water clarity in this lake than how the lake thermal structure actually was influenced during the years in this study period. Also, it has already been shown in previous studies (which the authors cite) that transparency impacts physical processes, and thus this is not a new finding. I suggest to replace the first sentence of this paragraph with specific strengths of this study.

Page 14, line 22. Change "Flake" to "FLake".

All figures in general. Include tick marks to all figures, both x- and y-axes. Also minor tick marks could be useful in some cases.

Fig. 1. Write the meaning of the acronyms in the caption or describe what the different stations are. Specify what are the vertical dashed lines.

Fig. 2. Write open what 'CC-derived' means.

Fig. 4. It is difficult to understand the caption and how it is exactly linked to the figure. Discuss the lines in the caption in the same order as in the legend of the plots. Write open what 'Obs', 'AvgXXXX', 'Merged', 'CRCM-12.6', and 'CRCM-20' mean. Assign (a), (b), and (c) to the subplots. What is the time resolution of the data? The general principle is that the reader should be able to understand the figure without having the need to constantly see the main text.

Fig. 9. It seems that the green line (CRCM-12.6) is missing from the plot. The last sentence of the caption seems out of place. The proper place should be in Results/Discussion.

Figs. 10-12. Show more values in the colorbars. Now only 0; 2.5 and 5 are shown, the interval should be at least 1 m-1 (i.e. 0, 1, 2, 3, 4, 5). Show the unit of the colorbar somewhere.