

Geosci. Model Dev. Discuss., author comment AC1
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Reply on RC1

Marco Toffolon et al.

Author comment on "SELF v1.0: a minimal physical model for predicting time of freeze-up in lakes" by Marco Toffolon et al., Geosci. Model Dev. Discuss.,
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Reply to Anonymous Referee #1

AR#1 - The authors propose a simple model of the seasonal lake cooling leading to formation of the ice cover. The model is calibrated and tested on data from alpine lakes and on outcomes of a one-dimensional process-based model. The model is of potential use in research on the lake ice cover formation and in lake-related applications. The fivefold variability of the main tunable parameter η between the five tested lakes (Table 2) raises however concerns about applicability of the model on large spatial scales. Another point of criticism is the description of model hidden largely in the supplemental, which is rather uncommon for a modeling journal and distracts the reader. Otherwise, the study is well conceived, applies adequate methodology and clearly written. Below are a couple of minor technical remarks.

We thank the Reviewer for the favourable general comments. Concerning the two elements of criticism, we provide specific replies in the following points.

- We agree with the Reviewer that the variability of the parameter η does not allow for imposing the same value for all cases. However, we do not expect η to be a universal constant because it includes two factors that are intrinsically varying from lake to lake: the efficiency of energy transfer from wind stress to internal mixing; and the representativeness of the meteorological station. Our preliminary analysis suggests that the former factor might be affected by lake depth (as we note in L302, "with higher values [of η] for shallow lakes ... and lower values for the deepest lakes ..."), but it is not possible to obtain a reliable dependence with only five values, nor to highlight the dependence on other physical variables. In any case, the latter factor (how meaningful is the measured wind speed for the actual conditions on the lake) may jeopardize any attempt in that direction, and confirm the need to find an ad hoc value of η for each pair of lake and meteorological station. Nevertheless, η is the only parameter that needs to be tuned in the model. If a sufficient long time record of measurements is available, the calibration is not a difficult task.
- Regarding the structure of the paper and the presentation of the details of the model, we believe that the essential information is already in the main text, where all the physical arguments are explained. The reader, after having had an overview of the model features, can rapidly go into the details provided in the Supplementary Material. We also want to stress that the discussion in the SM is not concerned with the SELF model, but with the theoretical background, the physical interpretation, and the

derivation of the approximate analytical solution.

AR#1 - L42: *The description of the models cited in this paragraph needs refinement. "Statistical approach" is not a proper definition here; the model of Rhode (1952) and Billelo (1964) is not statistical. Leppäranta did not propose any model of ice formation in his 1993 paper.*

The Reviewer is right. The models are based on a linearization of the heat fluxes between the atmosphere and the lake leading to a first order differential equation. We have removed the word "statistical" and restructured the paragraph. We also now refer to the work from Leppäranta (2014).

AR#1 - L168: *"The model SELF does not admit an analytical solution in closed formed." – the sentence is unclear. Does it mean the equation is not solvable in quadratures? Reformulate in a clearer way.*

We revised the sentence as: "The set of equations that composes the model SELF does not admit an analytical solution in explicit form, for instance in terms of a relation for the number of days n_d as a function of the forcing."

AR#1 - L238: *"a.s.l. (above sea level)" - replace with "above sea level (a.s.l.)"*

Corrected.

AR#1 - L249, L286, Fig. 3 and elsewhere: *Replace "performances" with "performance".*

Corrected.

Additional references:

Leppäranta M. (2014). Interpretation of statistics of lake ice time series for climate variability. *Hydrology Research* 45 (4-5): 673–683. doi: 10.2166/nh.2013.246