

Geosci. Model Dev. Discuss., author comment AC2
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Reply on RC1

Stanley G. Benjamin et al.

Author comment on "Inland lake temperature initialization via coupled cycling with atmospheric data assimilation" by Stanley G. Benjamin et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-409-AC2>, 2022

Thanks to the anonymous reviewer for a review of our lake initialization paper.

Responses are shown below as bullets and in italics.

This manuscript investigates a very important question of coupling lake to weather model. it is an important challenges for local predictions. in that sense, this study is an important one. I however do not support the publication of the current version of this manuscript for the following reasons:

- *Thanks very much for giving careful thought to our manuscript. We have some responses below to your concerns and suggestions. You are right that our manuscript does not add detail to the code structure of any lake model including the CLM lake model that we used. Instead, our paper was written to describe a lake initialization method unique in the United States, long-term forcing of the lake model at small lake points with hourly updated atmospheric conditions. In the US, the NOAA atmospheric models, up to this point, have been using a much simpler method using horizontally interpolated SST data to small lake points from values from much larger and usually far deeper bodies of water.*
- *It is very difficult to follow the scientific content of the paper. The manuscript seems to be very well suited for an internal report - where readers already know about the models details - and less to a scientific manuscript. The manuscript has to be profoundly revised. I do not see how other research group can benefit from this study with the current layout. I need much more technical details for a paper in GMD. Note that I am not questioning the quality of the work here.*
- *We presented early results on our data assimilation technique at the LAKE-2019 workshop in Toulouse. We were encouraged to submit a manuscript for this special GMD issue for papers based on presentations from that meeting even though our study was the initialization method. We added to the title of Section 2 that the Problem addressed in our paper is the Initialization Problem:*

L161: 2 **The Initialization Problem**

- literature review. The literature review missed many important contributions on the two way coupling lake atmosphere exchanges. I have added a non exhaustive list: I was surprised to not see references to COSMO/FLAKE (<http://www.borenv.net/BER/archive/pdfs/ber15/ber15-218.pdf> , <http://www.cosmo-model.org/content/model/modules/flake/>), Simstrat (<https://doi.org/10.1038/s41598-021-04061-6>), CRCM (<https://doi.org/10.1080/07055900.2000.9649657>) etc
- *Thank you for the references. The first of them (COSMO/FLake, Mironov et al 2010) was already referenced in the previous manuscript in the introduction but we have now added it to point out that COSMO produced a year-round reference dataset for lake temperatures. Moreover, we have added references to initialization for FLake by the Met Office and the original climatology data from Ekaterina Kournezova et al (a new reference not previously cited).*

Below is the new rewritten section L91-110, new/modified text is underscored:

*However, lake temperature initialization can still be a problem. Use of spatial interpolation to smaller lakes from larger (and deeper) lakes, or from the ocean, for lake initialization (e.g., Mallard et al, 2015) can exaggerate this seasonal slower response. Shallow lakes warm more slowly in spring than surrounding land, but more quickly than nearby deeper lakes. Even in summer, it will take at least 1-2 weeks for 1-d models to adjust from values interpolated from deeper-lake temperatures to become more realistic for shallow lakes. Therefore, lake temperature initialization becomes the most important factor to accurately simulate sensible and latent heat fluxes from lakes for short to medium-range NWP, more so than the use of the lake model itself. One option to solve the lake initialization problem is to use a model-based climatology for seasonal variation of lake temperatures (Balsamo et al (2012) and Balsamo (2013), **ECMWF**) using a 1-d lake model forced by reanalysis data. **The 1-d model used by ECMWF is the 2-layer FLake (Freshwater Lake Model) model (Mironov et al, 2010, Balsamo et al, 2012, Boussetta et al, 2021) implemented into their Integrated Forecast System (IFS) in 2015. A similar technique was applied by Mironov et al (2010) using FLake for the COSMO model. Kourzeneva et al (2012a) describe application of 20-year reanalysis data to a global lake dataset using FLake for this lake temperature climatology. This technique avoids a new spin-up with each new run, but cannot capture unique weather regime variations in a given region and time. The UK Met Office uses satellite data to update their lake surface water temperatures using the previous day values as a background (Fiedler et al, 2014).** Another option, described here, is lake cycling with the ongoing 1-d lake prediction model fully coupled with an NWP model, a cost-free option if the atmospheric conditions are relatively accurate.*

- Figures. I do not see the added values of most figures showing maps of North America. Figures looks more like print screens than carefully designed visual information.
- *Figures 1 and 2 are informational to give some idea on the horizontal lake representation in the 3km HRRR model. They will be of sufficient quality to be expanded for detailed visual inspection in the final article.*
- L37 "errors in lake temperature from as much as 5-10K " I am not aware of any model with such range of error. This error range does not make sense.
- *Thanks very much for asking this question, and it allows us to further underscore the*

main purpose of our technique and paper. Unfortunately, NOAA in the US has been using, for lake temperatures, a horizontal interpolation of deep-water SST data (see our Fig. 3 and related discussion). Many of the different lakes in our key results in our Fig. 9 show likely temperature errors of 5K and even up to 10K (e.g., lake #15 in Fig. 9 in July). We would agree that there could not be lake temperature difference of 5-10K comparing a reanalysis-driven annual lake temperature data and what we have done with real-time cycling. But we have definitely found such differences compared with the NOAA SST data with horizontal interpolation to small lakes.

- L86 "However, lake temperature initialization is still a problem." It is not clear why it is a problem. 1-D models are fast to run and can easily be run for long period with no memory from the initial conditions.
- We changed the wording from "... is still " to "can still be" in what is now L91 (see earlier response). You are right - the use of the reanalysis-driven generations of lake temperature climatology has been effective but had not used yet by NOAA. So, our effort is unique within NOAA. Perhaps the cycling of ongoing prediction of the lake temperatures through the model (every 20 seconds for 3km HRRR) is unique also.
- We have revised Table 4 to reflect the additional lake initialization treatment used by the Met Office but also to distinguish the 2-way cycling from the reanalysis-driven lake climatology. As of this writing today, we co-authors are gathering more information on the Met Office effort and applications toward NWP of the Copernicus lake surface water temperature data.

Consequences (to right) from strategy for lake initialization (below)	Coupling lake and atmosphere within initialization	Lake temps in spring-summer	Lake temps in fall
SST interpolation to small lakes	None	Much too cold, especially for shallow lakes	Still generally too cold but intermittently too warm after cold-air outbreaks.
Lake annual variation forced by reanalysis atmospheric data – 1-way cycling from atmospheric forcing	1-way	More accurate. No weather regime variation in a given year	More accurate. Will not capture variation from weather regimes in a given year.
Daily updating with satellite data	None	More accurate but cannot keep up with changes during cloudy	More accurate but cannot keep up with changes during cloudy

periods.

periods.

2-way cycling

2-way

More accurate including response to specific yearly/seasonal anomalies.

More accurate including yearly/seasonal anomalies

- I question the reproducibility of this study. The authors do not provide their codes/working examples. Again, I do not see how other research group can benefit from this study. This study is not FAIR-compliant and do not make a contribution valid for GMD in the present form.
- *The effort to reproduce this study would be very large, since it is an outcome from a 3km model integrated over much of North America for a few years. However, the code necessary to match a shorter period is shown in the code availability statement (through the community WRF model) and the HRRR data are also available for an initialization through Amazon Web Services as shown in the data availability statement. The availability statements are after the text, now in L729-738 in the new version.*

Thank you again for raising key questions that have resulted in important improvements in our manuscript. Do our responses clarify our purpose and at least partially address your concerns?