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# *Interactive comment on* "Technical challenges and solutions in representing lakes when using WRF in downscaling applications" *by* M. S. Mallard et al.

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The authors are thankful for the constructive criticism and commentary provided by Reviewer #2. We address their comments point-by-point below. The reviewer's original comments appear in quotations below and our responses follow. All page numbers referring to the manuscript in our responses below are valid for the revised manuscript with track-changes used to show corrections. The revised manuscript is provided as a supplement to our response to Anonymous Referee #1.

"This paper presents a brief overview of several problems in generating lake surface temperatures from global climate models (GCM) with underrepresentation of lakes to be used to run WRF as a regional climate model (RCM). It gives a good deal of information about many of techniques that can be used to achieve this, as well as the



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drawbacks from these methods. While most things are considered, there are a few areas that could use further explanation. Most of these are minor in nature."

Overall Comments:

"I think some background information on how WRF, being run as a regional climate model, treats lakes would be beneficial for context."

We have revised the introduction (see p. 2, lines 35-38, lines 42-46) to provide further understanding of how WRF functions as an RCM in its default configuration without a lake model. We also address your more specific questions below.

"Are surface properties like lake temperature taken from the GCM at each time step, or does the land surface model within WRF deal with this temperature calculation?"

A sentence has been added on p. 2, lines 42-46 to clarify this. In its default configuration with no lake model used to prognosticate lake surface temperatures (LSTs), LSTs are calculated in the preprocessing steps before WRF is run and then prescribed to the model at runtime. Therefore, the land surface model plays no role in calculating lake temperature. The frequency with which the prescribed temperatures are read is set by the user, but it is commonly set to daily or sub-daily, depending on the user's application and availability of driving data.

"When temperatures are initialized or a scenario without a lake model, is it simply a one-layer slab model, or multiple layers similar to land points? Does WRF apply a diurnal cycle?"

As stated above, when no lake model is used, lake (and ocean) surface temperatures are simply read in from an input file after having been interpolated from the driving dataset. This is further clarified in the manuscript on p. 2, lines 35-38. Although a diurnal cycle should be present in any well-vetted, observationally-based sea surface temperature (SST) data used to drive the WRF model, no adjustment is done by WRF to create a diurnal cycle in water temperatures. This presence of a diurnal cycle is also



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sensitive to the frequency with which the user updates the prescribed water temperatures [i.e., whether the user specifies a sub-daily (3- or 6-h) frequency to read SSTs into the model]. Although this aspect of the model settings can be arbitrarily chosen, we briefly mention that the commonly used timescales in the revised text (p. 2, lines 42-46).

"I think answering some of these questions would help to put some of the methods into better context and show how errors in initialization may propagate in a model, especially when no lake model is being used."

The reviewer's questions indicate that further explanation of how WRF prescribes water temperatures is needed in the introduction in order to avoid confusion later in the manuscript. The revised article has been corrected to include more general description of WRF's treatment of water temperatures, as discussed above.

Specific Comments:

1. "Pg. 7124 line 21- Pg. 7125 line 2. I am not sure this paragraph is entirely needed. The previous paragraph describes the same situation with visuals that is shown by M14. Some further explanation is either needed to show how this is a different problem than what is presented in Figures 1 and 2, or this section should be pared down. This section could also be worked into the first paragraph of Page 7126."

We feel that that this paragraph illustrates the motivation for the study best in its current position because it provides an example of how lake temperatures are set when the lake is partially represented by the GCM. This contrasts well with what is shown in Figs. 1 and 2, where the Great Lakes are not represented at all. An additional sentence has been added on p. 4, lines 101-104 to state this contrast and put the paragraph in better context.

2. "Pg. 7130 Section 2.2. Has this method been used by any other study? You state that linearly increasing lake states maybe useful for some lakes, but you give no



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examples of this approach being employed. It seems like this approach offers very little in terms of realism and upside, so is it necessary to be mentioned?"

We have not found examples of this approach being used. However, the use of stationarity assumptions is ubiquitous in regional climate modeling, where future simulations are routinely run with the same land-use and vegetation fields that are used to simulate the present-day climate. Therefore, it seemed necessary that we examine how the option of using present-day lake surface temperatures and ice cover could affect a future simulation. Warming lake temperatures by a constant rate or using a linear increase would be a logical next step to improve the accuracy of such a method; however, we do not have a specific example, either in this work or by referencing another, to illustrate this. To put this work section in further context, we have added a sentence on p. 9, line 260-261 to clarify why this option is discussed.

3. "Page 7131 Section 2.3. In the use of this method, I understand where the land-lake temperature contrast would be lost, at least in the short-term. But given enough spinup time (similar to what is shown in section 2.6), could these contrasts be generated from lake-atmospheric interactions, or is this still a case of poor initialization leading to poor results?"

In this methodology, as applied by Gao et al. (2012), no lake model is run and WRF uses prescribed water temperatures which are calculated during the preprocessing steps before the WRF simulation begins. Therefore, it can simulate only a one-way interaction between the atmosphere and the lake (i.e., the lake state impacting atmospheric conditions). Because this is a one-way interaction based on prescribed lake temperatures from the driving data, even with a protracted spin-up time, the lake temperature could not be forced to produce a lake-land temperature contrast.

4. "Page 7135, lines 8-10. What do you mean by 'looped' here? Do you mean using the atmospheric conditions from the year 2005, and ran that same data 10 times while allowing the lake conditions to evolve? Some clarification might be beneficial here."



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The reviewer's understanding of how we ran the model is correct. We have revised the wording (p. 13, 387-393) to state this more clearly.

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Interactive comment on Geosci. Model Dev. Discuss., 7, 7121, 2014.



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