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Geoscientific Model Development Discussions

Interactive comment on "The regional climate model REMO (v2015) coupled with the 1-D freshwater model FLake (v1): Fenno-Scandinavian climate and lakes" *by* Joni-Pekka Pietikäinen et al.

Anonymous Referee #2

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General comments

The manuscript presents a study of the impact of a lake model, FLake, in the regional weather model REMO over several decades. Results are presented of mean seasonal biases over the study area, together with mean annual and seasonal evolution at a number of selected lake sites.

The main finding of the study is that FLake produces good lake surface properties, perhaps despite the characteristics of the model within which it is embedded. However, its inclusion exacerbates the worst existing model biases, and the modelled internal lake temperature structure may not be a good representation of the measured lake

temperature profiles.

In terms of its significance, it adds to a number of studies (not all cited here) validating the use of FLake in global or regional weather or climate models. Previous examples may be seen in the special issue of Boreal Environment Research (vol.15(2), 2010), and the Tellus thematic cluster "Parameterization of lakes in numerical weather prediction and climate models".

Specific comments

Section 2.1
Given the apparent model biases, and later error attribution, the description of the boundary-layer and surface-exchange representation of REMO is inadequate. Of the references given (p3, line 22), Kotlarski (2007) is a PhD thesis and Rechid (2009) is no longer available at the URL cited. In any case some description of the main points should be given here rather than relying solely on references.

The description of tile structure is also confusing. It is stated that there are 3 tiles: land, ice and water (p3, line 23), but then that the standard land-surface scheme does not have a tile for lakes (p3, line 25). So does "water" mean "sea water", as on p4, line 15?

Section 2.3
P4, line 19: The GLCC lake fractions were used instead of those from Choulga et al (2014), although the latter are consistent with the depths taken from the same dataset. How do the two lake-fraction datasets compare?

P4, lines 25–26: The fractional ice-cover in the original model is replaced with binary ice cover when FLake is implemented. It is possible that this change on its own may affect the model results. Its impact should have been estimated.

P5, lines 8–15: There is some discussion of heat conductivity for lake ice and snow on lakes, but no discussion of how snow on land is modelled. Snow heat conductivity is taken as a single number (0.14 W/(mK), p5, line 14) despite the fact that snow density

is apparently not fixed (p5, line 9). Studies such as Calonne et al. (GRL 2011) show that conductivity varies greatly with snow density, and the weighted sum of equation (1) presumably acts partly as a substitute model for this variation. It may be speculated that over-simplistic representation of snow conductivity generally may contribute to the winter cold bias even in the control run.

Section 2.4
Snow albedo gets a subsection here, although the rest of the snow scheme is not described. As stated later (e.g. p10, line 33), albedo changes may have little effect in winter given the lack of solar radiation in these regions then, so the emphasis on this aspect needs more justification.

P5, line 29: The forest fraction mentioned here should have been described earlier in section 2.1.

P6, lines 3–11 seem to be a repeat of the previous paragraph.

Section 2.5
P6, line 32 – p7, line 2: The model end-state (in March?) is used as the model initial state (in August?). Would it not have been more suitable to use an initial state from the same season, say from August of the penultimate year?

P7, lines 5–6: Given that one comparison is with 2 m temperature, the height of the lowest model level should be stated, as also the surface interpolation scheme should earlier have been described.

Section 2.6
P7, line 31 – p8, line 1: Apparently 7 out of the 18 chosen study lakes may have unrepresentative mean depths in the model dataset. However, lake depth is often described as the parameter to which FLake is most sensitive. Is the study intended to test, or contradict, this assertion?

Section 2.6

P 8, line 32. “The reason for the [control-run] cold bias is still unknown.” Given that on p2 (lines 7–9) it is anticipated that a better lake representation will reduce wintertime heat fluxes, it seems odd to prioritise implementation of a lake model into a weather model with an existing, unexplained winter cold bias. Not least, it undermines the ice thickness/duration comparison. (As an aside, does the cold bias correlate with snow depth, as hinted by p9, lines 4–5?). The neglect of the cold-bias problem is acknowledged, but not really explained, in the last Conclusion paragraph.

As a related point, the discussion on p11, lines 3–7 seems to say that the snow conductivity has been adjusted over lakes only, but acknowledges that snow thermodynamics may be a large factor in the cold bias. So why not try and improve “land” snow behaviour before applying FLake?

Section 4.1
P11, lines 27–32: “The underestimations in the model during spring can be mostly explained by these factors.” The factors are discussed in a rather vague and unquantitative way, hence the proposed explanations are not very convincing.

P12, lines 1–6: Errors are attributed to having the wrong mean lake depth, or to river input/output. It might have been better to adjust the depths of the study lakes, at least, to try and differentiate between these possibilities. Not least, it would be interesting to definitely attribute errors to river flow (or not), since this has a bearing on the general usefulness of 1-D models with no hydrological connections.

P12, lines 23–24: “Naturally, there are no thickness measurements for the beginning or end of the ice season as the ice is too shallow to make these manual measurements.” Does this mean the thickness measurements are biased high?

P12, line 30 – p13, line 18; Again, the reasons for discrepancies are discussed in a qualitative way, with no quantitative testing or discrimination between the possible causes of error advanced.

Section 4.2
Figure 5: It appears that the surface temperature at Vörtsjärv is above freezing during some or all of the ice-covered period?

P13, line 28: “the main problem is the cold bias [of] the model.” I believe this supports my earlier point about priorities.

Section 4.3
Figure 6: I do not find the different (arbitrarily chosen?) depth scales for model and measurement profiles to be a useful way of making this comparison. Instead, profiles with a common depth scale should be shown. Then the authors can discuss (or the reader can decide) whether FLake gets the correct surface behaviour despite, or because of, its internal lake-structure model.

Technical points

Title: Should it be “freshwater **lake** model FLake”
p1, line 10: “are in realistic.” ?
p3, line 8: use NWP as defined on p1.
p4, line 11: Remove “on”
p5 line 1: Does “It” refer to FLake?
Equation (1): hs does not seem to be defined.
p5, line 19: tp -> to
p10, line 27: tot he -> to the

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