Authors' response

Response to Referee #1

Submitted on 22 Jan 2021

Accepted as is

We thank again Referee #1 for his/her suggestions to improve this manuscript.

Response to Referee #2

Submitted on 05 Feb 2021

The authors have adjusted the study, removing the most obvious discrepancies between the modeling results and their interpretation with regard to the real physical objects (ice-covered lakes). The remaining arguments on the role of the latitudinal variability of the Coriolis force are not fully convincing, but they are put in a more or less acceptable context. The study can be published with a couple of minor but important (!) corrections, allowing the dedicated reader to get an unbiased picture of the presented results:

We would like to thank again Referee #2 for his/her thorough review of this manuscript

Line 155: \. . . to several kilometers in length" should be replaced with \up to the maximum of ≈ 1 km".
Explanation: the order-of-magnitude analysis, when performed properly, should use the fixed f = O(10^{-4}). The variations of ±30 % from the mean value are neglected in the order-of-magnitude estimations. Even if accounting for the minor variations of f, in the given velocity range of two orders of magnitude and Ro = O(10^{-1}), the maximum length scale is ~ 1.6 km, which is far below "several kilometers". As the study clearly shows, the ageostrophic, Ro = O(10^{-1}), regime is generally not applicable to lakes with the horizontal scales > 1 km.

AR (Authors's response) 1: We have clarified this in the text. Even if we use $f = 10^{-4}$ s^{-1}, the ageostrophic regime would approximately cover $0.1 \lesssim Ro \lesssim 1$ (note that this work does not define the exact limit between the ageostrophic and transition regimes). If we use $Ro = 0.1$ (the lower approximate limit of this regime), L would be 0.5 km for $U = 0.005$ m s^{-1}, but 5 km for $U = 0.05$ m s^{-1}. L represents one-half of the width of the lake (the radius if of circular shape) so, lakes with lengths up to approximately 10 km could potentially still be in this regime. We will clarify that we refer to the total length ($2L$) in the text. But, we agree with the reviewer that the sentence "lakes ranging from several tens of meters to several kilometers in lengths" may lead to confusion and now we express this length also in terms of order of magnitude, so the text now reads "*For a range of measured radial velocities of O(10^{-3}–10^{-2}) m s^{-1} under ice (Forrest et al., 2013; Kirillin et al., 2015; Rizk et al., 2014),* ***a value of Ro O(10^{-1}) could be representative of lakes of O (10^{-1}-10^{0}) km in length (~2L)***"

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Line 352: After ". . . should be common under ice . . . " a phrase has to be added: "for lakes with horizontal dimensions ≲ 1 km".

Explanation: see the remarks above. Here, the over-generalization (should be common under ice . . .) is not supported and can misguide the reader, because Ro = O(10^{-1}) is only true for small ice-covered lakes with relatively high horizontal velocities (irregular hypsography).

AR2: This sentence refers to Fig. 5b, where we see that this regime would be common at all latitudes. We have clarified in the text that this is because there is a bias in the lake size distribution towards smaller lakes. More than 85% of lakes on Earth have surface area < 1 km^2 (Messager et al., 2016). The text now reads "***The bias in the distribution of lake size towards smaller lakes (more than 85% of lakes on Earth have surface areas smaller than 1 km^2, Messager et al., 2016****) and the bias in the potential for ice cover formation (e.g. Sharma et al., 2019) and the distribution of lakes on Earth towards mid to high latitudes (> 45° N, Fig. 5b) indicates that the ageostrophic regime with Ro O(10^{-1}) should be common under ice as shown by the mean (red lines) values in Fig. 5d*."

Line 298: "Winter I period". It is better to remove the word "period". Depending on climatic conditions, a lake may have only "Winter I", or only "Winter II" throughout the entire ice-covered period. The terms "Winter I/II" have not became widespread yet; it is better to cite Kirillin et al. (2012) at their first appearance to provide the reader with a necessary background.

AR3: We agree with the reviewer. We have removed the term "period" after "Winter I" and "Winter II" and have included the reference to Kirillin et al. (2012), the first time we mentioned them in the text.