Reply to RC2 for the manuscript "Satellite Microwave Assessment of Northern Hemisphere Lake Ice Phenology from 2002 to 2015" by Jinyang Du, John S. Kimball, Claude Duguay, Youngwook Kim, and Jennifer D. Watts

Dear Anonymous Referee #2, thank you for your helpful comments on our manuscript. Please find below our responses to all the comments (in ***bold and italic***). The changes on the manuscript were highlighted in blue.

This manuscript presents a new methodology to apply the use of passive microwave imagery (AMSR-E/2) to create an automated daily ice phenology product utilized for monitoring freshwater lake ice. The daily temporal ability, unhindered by cloud and polar darkness allows for a global product at a resolution and accuracy that can of benefit climate modelling and global change studies. This manuscript is well written and a valuable contribution to the freshwater ice research field. The inclusion of cited literature is light in the introduction section and could use some strengthening; however overall, the manuscript is clear, concise and suitable for publication with only minor revision to the text and figures.

No particular scientific issues arise from this review. The validation of the new passive microwave based product is limited by the lack of existing observation data from lakes, however including the comparison to the CIS dataset and the IMS product strengthens the validation sufficiently.
Reply: Thank you for the comments.

The following is a list of some minor typographical suggestions and some points to clarify the figures:

Line 11 : Previous studies have documented significantly earlier ice break-up between 1951 and 2000 for lakes in Canada (Duguay et al., 2006) and decreasing lake ice cover of Lake Ladoga in Europe during the last few decades (Karetnikov and Naumenko, 2008). – Consider adding more than 1 citation for each broad area of research
Reply: As suggested by the reviewer, the sentences were revised with more citations added as follows: "Previous studies have documented significantly earlier ice break-up between 1950s and 2000s for lakes in Canada (Duguay et al., 2006; Latifovic and Pouliot, 2007; Prowse et al., 2011) and decreasing ice cover duration of Eurasia lakes during the last few decades (Vuglinsky and Gronskaya, 2006; Karetnikov and Naumenko, 2008; Prowse et al., 2011)."

The added references were listed below:

"Vuglinsky, V.S. and Gronskaya, T.P.: Changing of rivers and lakes ice regime within the Russian territory and their possible consequences for economy, Modern problems of hydrometeorology, 229-245, 2006.

Prowse, T., Alfredsen, K., Beltaos, S., Bonsal, B., Duguay, C., Korhola, A., McNamara, J., Pienitz, R., Vincent, W.F., Vuglinsky, V. and Weyhenmeyer, G.A.: Past and future changes in Arctic lake and river ice, Ambio, 40(1), 53-62, 2011."

Line 16: various tendencies over specific lakes and : : : Such as?
Reply: The sentences were revised to improve clarity as follows:
"Despite a general tendency for later freezing and earlier break-up in the Northern Hemisphere (Magnuson et al., 2000), various tendencies including earlier ice formation and later ice break-up over specific lakes and time periods may exist. For example, observations from satellite altimetry and radiometry over 1992–2004 for Lake Baikal showed a tendency for colder winters, with earlier ice formation, later ice break-up, and ice duration increase (Kouraev et al., 2007a, 2007b)."

Page 3 line 12: Recently, H-Polarized AMSR-E (Advanced Microwave Scanning Radiometer for EOS) Tb observations at 19 GHz were analyzed to determine ice phenology for GSL and Great Bear Lake (GBL), the two largest lakes in northern Canada (Kang et al., 2012). – again, consider using more than 1 citation for the work done here
Reply: The AMSR-E lake ice detection method described here was mainly developed in (Kang et al., 2012) and extended in (Kang et al., 2014). As suggested by the reviewer, additional citation was listed as below: "Recently, H-Polarized AMSR-E (Advanced Microwave Scanning Radiometer for EOS) T_b observations at 19 GHz were analyzed to determine ice phenology for GSL and Great Bear Lake (GBL), the two largest lakes in northern Canada (Kang et al., 2012; Kang et al., 2014)."

Page 3 (line 30, 31) - 4 (line 1) study domain – The explanation of the study purpose does not belong here.
Reply: We accepted the reviewer's comment and deleted the sentence "Accurate monitoring of seasonal land freeze/thaw and lake freeze-up/break-up events which are widespread in the Northern Hemisphere has been recognized as an essential component for understanding interactions and feedbacks between regional ecosystems and climate change (Duguay et al., 2006; Kim et al., 2012; Du et al., 2015a)".

Page 4, line 4 – arctic region "Global Warming" – consider a more scientific term. E.g. Arctic amplification effect? More extreme climate warming than lower latitudes?
Reply: As suggested by the reviewer, the sentence was revised as follows "The domain (Fig.1) includes the high northern pan-Arctic region and high altitude Qinghai-Tibetan Plateau, which are data-sparse but strongly sensitive to the Arctic amplification effect (Serreze and Francis, 2006; Woo et al., 2007) and/or elevation-dependent warming (Wang et al., 2011; Mountain Research Initiative EDW Working Group, 2015)."

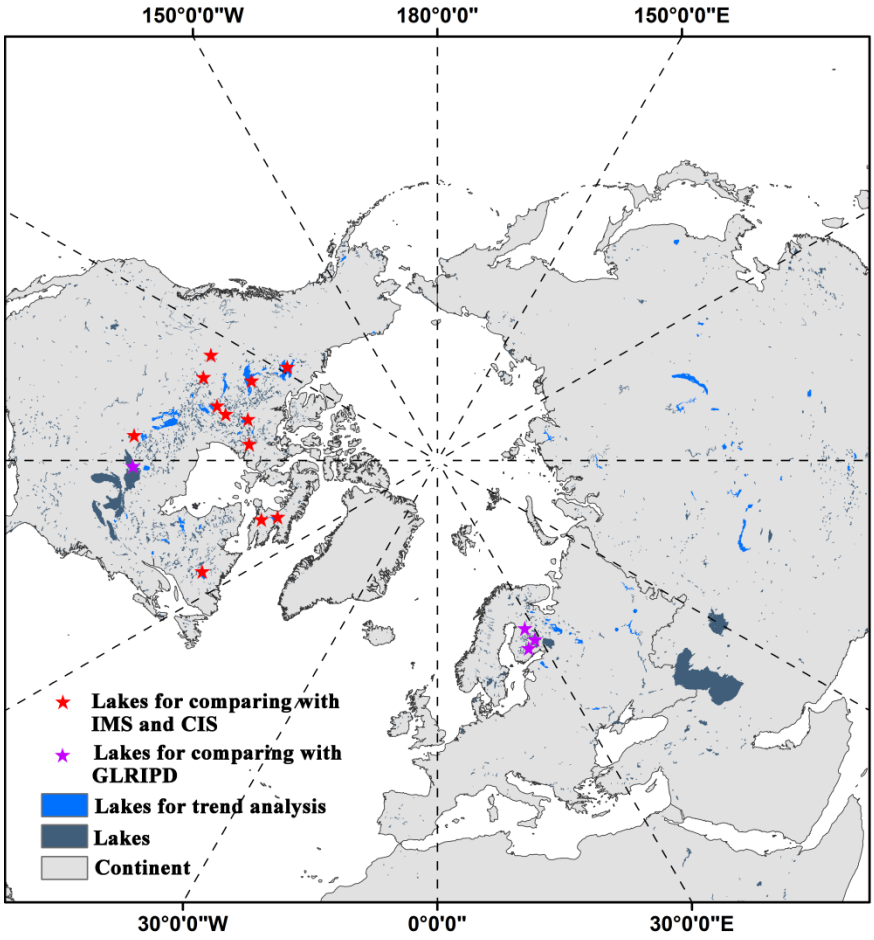
The following references were added in the revision:
"Serreze, M. C., and Francis, J. A.: The Arctic amplification debate, Clim. Chang., 76(3-4), 241-264, 2006.

Mountain Research Initiative EDW Working Group: Elevation-dependent warming in mountain regions of the world, Nat. Clim. Chang., 5(5): 424-430, 2015."

Page 4, line 9 - Lake Superior is in Canada And USA.
Reply: We made corrections throughout the manuscript. The revisions include paragraph 1 of page 4 ("Lake Superior in the USA and Canada") and the captions of Fig.1 ("Lake Superior in the USA and Canada") and Fig.2 ("Lake Superior, USA and Canada").

Page 11 line 15 – ICDe? Was that defined previously? Why an e?
Reply: The ICDe abbreviation was defined in Table 1 and was adopted from previous studies (Kang et al., 2012; Duguay et al., 2015a). "e" here represents "entire lake". To be clearer, ICDe in Table 1 was re-defined as "Ice cover duration of entire lake (ICDe)".

Figure 1 – needs more distinguishable blue colours for the trend analysis lakes.
Reply: As suggested by the reviewer, Fig.1 was re-plotted with more distinguishable blue colors as shown below.



Lake Superior is listed as USA – Lake Superior is in Canada as well.
Reply: We made corrections throughout the manuscript. The revisions include paragraph 1 of page 4 ("Lake Superior in the USA and Canada") and the captions of Fig.1 ("Lake Superior in the USA and Canada") and Fig.2 ("Lake Superior, USA and Canada").

Countries are listed for the GLRIPD lakes but not the other comparison lakes – why? Be consistent, either remove the countries for the GLRIPD lakes or add them for all lakes.
Reply: As suggested by the reviewer, we added the country names for the other comparison lakes in the caption of Fig.1 and section 2.1.1 as follows:
"… The red star symbols denote 12 lakes (Great Bear Lake, Great Slave Lake, Smallwood Lake, Nettiling Lake, Dubawnt Lake, Amadjuak Lake, Wollaston Lake, Baker Lake, Kasba Lake, Lesser Slave Lake, and Peter Pond Lake in Canada; Red Lake in USA) …"

"And 12 North American lakes (GBL, GSL, Smallwood Lake, Nettiling Lake, Dubawnt Lake, Amadjuak Lake, Wollaston Lake, Baker Lake, Kasba Lake, Lesser Slave Lake, and Peter Pond Lake in Canada; Red Lake in USA)…"

Figure 2 – clarify what the "dots" are – not clear initially what is going on this figure. Clearly indicated the "dots" represent ice cover vs. open water (?)
Reply: The blue/red dots represent GLRIPD/LIP derived ice conditions as indicated by their Y-axis positions for the dates described by their X-axis coordinates. To be clearer, caption of Figure 2 was revised as follows:

"Figure 2. Comparison of lake ice status for Lake Superior, USA (a), Lake Oulujarvi, Finland (b), Lake Haukivesi, Finland (c) and Lake Paijanne, Finland (d) derived from the Global Lake and River Ice Phenology Database (GLRIPD) and AMSR-E/2 Lake Ice Phenology retrievals (LIP). The AMSR 36.5 GHz H-Polarized daily Tb retrievals used in the LIP algorithm are also plotted for reference (black line). The blue/red dots represent GLRIPD/LIP derived ice conditions as indicated by their Y-axis positions for the dates described by their X-axis coordinates."

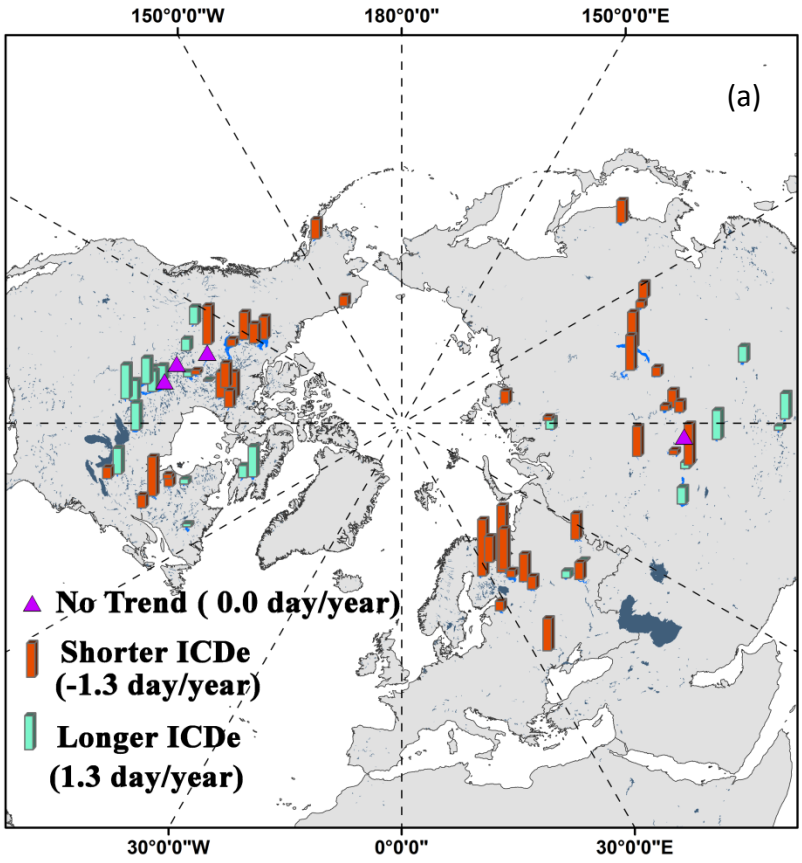
Figure 3 – This is a very unnatural projection for GBL, is there a specific reason to display this way? If so, it was unclear from the text. Consider reprojecting to a projection that is more realistic of the actual size/shape of the lake.
Reply: Fig. 3 was plotted under EASE-GRID version 2 to be consistent with the AMSR-E/2 gridded T_b data as described in Section 2.1.4. The EASE-GRID projection is a standard format for cryosphere products including sea ice retrievals derived from passive microwave sensors AMSR-E and SSM/I (https://nsidc.org/data/seaice/pm.html). To be clearer, we revised the caption of Fig. 3 as follows:

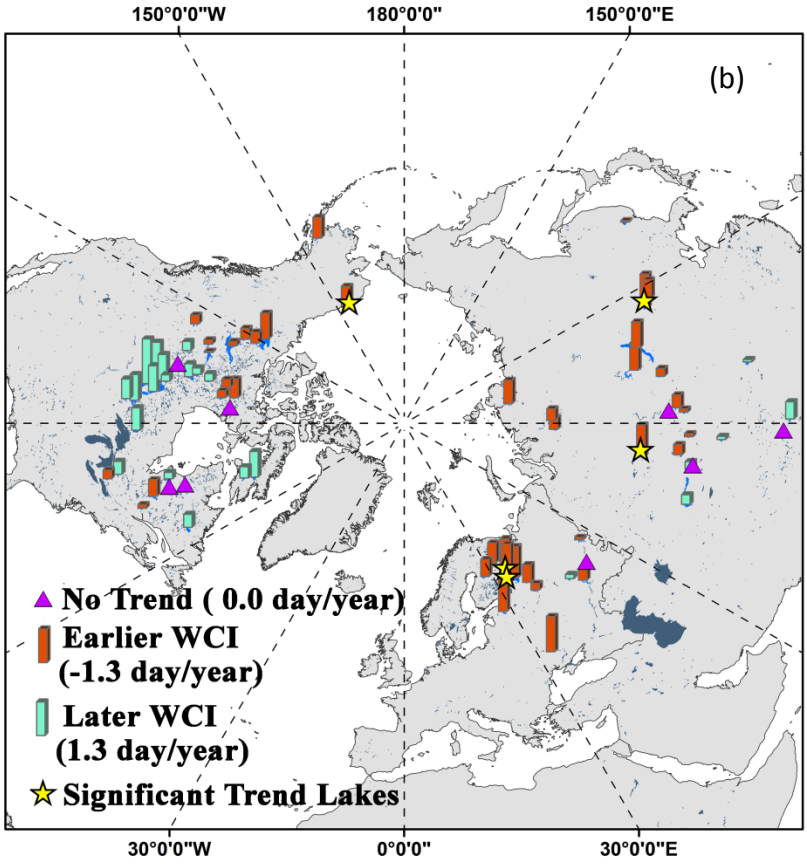
"Figure 3. Comparisons between MODIS quick-look images (left column) and AMSR LIP results (right column) for Great Bear 5 Lake (GBL) on Jun. 22 (a), Jun. 27 (b), Jul. 5 (c) and Jul. 8, 2013 (d). The images are in the EASE-GRID version 2 polar projection format, consistent with the underlying AMSR-E/2 gridded T_b dataset used for the LIP classification."

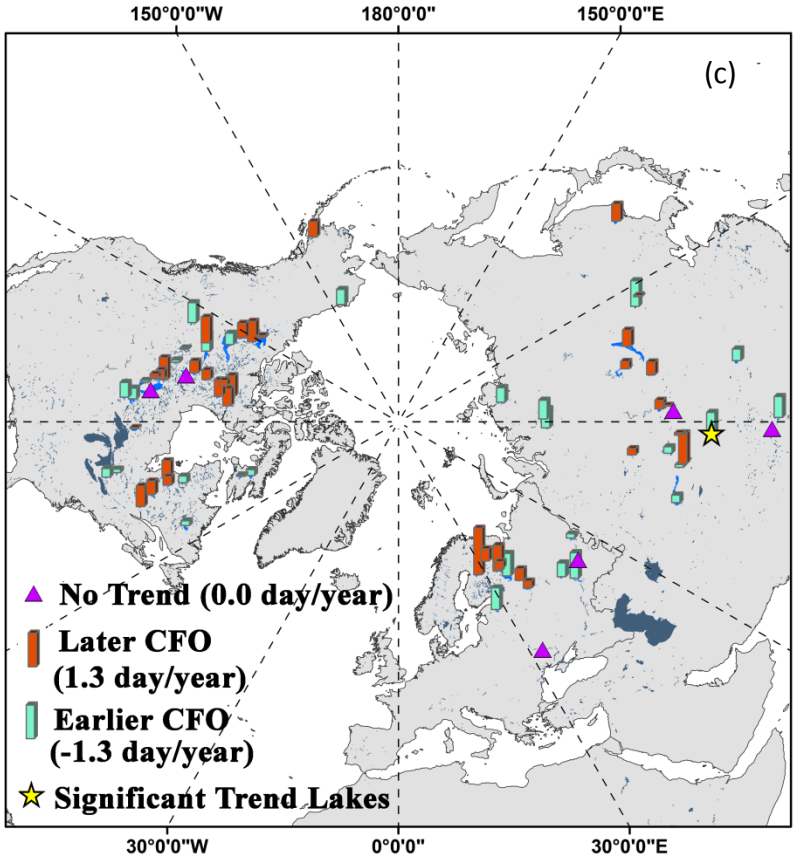
Figure 5 – ICDe? Again, why the e?
Reply: The ICDe was defined in Table 1 and previous studies (Kang et al., 2012; Duguay et al., 2015a). "e" here represents "entire lake". As replied previously, ICDe in Table 1 was re-defined as "Ice cover duration of entire lake (ICDe)".

b and c are too small to interpret the symbols / heights of the bars. Consider making all 3 the same size.

Reply: We followed the reviewer's suggestion and made Fig.5 (a), (b) and (c) the same size to improve its clarity as shown below.




150°0'0"W
180°0'0"
150°0'0"E
(b)
No Trend (0.0 day/year)
Earlier WCI
(-1.3 day/year)
Later WCI
(1.3 day/year)
Significant Trend Lakes
30°0'0"W
0°0'0"
30°0'0"E


150°0'0"W
180°0'0"
150°0'0"E
(c)
No Trend (0.0 day/year)
Later CFO
(1.3 day/year)
Earlier CFO
(-1.3 day/year)
Significant Trend Lakes
30°0'0"W
0°0'0"
30°0'0"E