Interactive comment on "Estimating ice phenology on large northern lakes from AMSR-E: algorithm development and application to Great Bear Lake and Great Slave Lake, Canada" by K.-K. Kang et al.

Anonymous Referee #2
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The comment was uploaded in the form of a supplement:
http://www.the-cryosphere-discuss.net/5/C1629/2011/tcd-5-C1629-2011-supplement.pdf

We appreciate the anonymous reviewer #2 for helpful and insightful comments for this manuscript.

Referee comment: *This is a well-written, well-organized and well-illustrated paper. It presents the results of original research and makes a valuable contribution to knowledge and understanding of passive microwave remote sensing as a tool for deriving ice phenology, in this case on two very large northern Canadian lakes – Great Bear and Great Slave. Lake ice phenology is an important indicator of climate variation and change and, at a time when observation networks on the ground have been greatly diminished by short-sighted governments, the results of this paper are particularly important as they show that accurate large lake ice phenology records are possible using passive microwave remote sensing. In this regard I think that the authors are being a little too modest about the new algorithm and how their results compare with lake ice phenology records derived by other means. I would say that their work is a significant advance and that the results are the better than those derived by other means. It is to be hoped that the new algorithm will be adopted to document lake ice phenology at a larger number of lakes in the future (and that a quantification of uncertainty/biases will be attempted – see p. 17, lines 2-3), and applied retrospectively to older passive microwave data to extend the phenology record back in time*.

General comments 1: *I recommend avoiding the use of 'phonological' and instead use 'phenology' exclusively.*

→ Corrected throughout the paper.

General comments 2: *The 'cross-' in 'cross-compare' and 'cross-comparison' is redundant. One need only use 'compare' and 'comparison'.*

→ Corrected

General comments 3: *This paper describes phenology 'variables' not phenology 'parameters'. Parameters are invariant. Freeze onset, ice-on etc are very definitely variable, as demonstrated in this paper. Thus they are variables.*

→ We substituted 'parameters' by 'variables'.

General comments 4: *Melt onset (MO) must be defined early in the paper rather than waiting until p. 14, line 25.*

→ Melt onset (MO) was first mentioned on p. 5 where we also made reference to Table 1. This table contains the definitions and acronyms of all ice phenology variables.

General comments 5: *Melt Sections 5.1.1 and 5.1.2, but particularly 5.1.2, contain much extraneous information as the authors apparently attempt to explain the Tb variability. I don't think this is necessary, particularly as the explanations derive from observations often made elsewhere in studies not concerned with Tb. Thus I see no need for the material on, e.g., fluxes and heat exchange, snow ice and clear/black ice, etc….*

→ We agree with this comment. We have now removed most of the material as suggested.

General comments 6: *Regarding Section 5.3, did the authors experiment with different thresholds and those presented in this section are the optimum thresholds? If there was experimentation, do we need to see some of those results in the paper?*

→ Trial and error is a common approach for detecting thresholds (e.g. Wang et al. 2008-RSE) and the thresholds in this case do represent optimum values. Following other studies (i.e. Markus et al., 2009-JGR; Howell et al., 2009-RSE; Wang et al. 2011-JGR) we have chosen not to include them because it adds unnecessary information to the manuscript.

General comments 7: *The results presented in Section 6 can be fairly dense and difficult to follow due to the level of detail. I recommend making life a little easier for the reader by referring only to the earliest and latest dates of events. There is no need to describe events that closely follow the extremes.*

→ We agree with this suggestion. As a result, we have just focused on the extremes.

General comments 8: *The paper has nine tables. This is rather a lot, but perhaps it doesn't matter so much in an online publication. Nonetheless, it will be a dedicated reader who ploughs through all that detail.*

→ We feel that presenting results in some details is justified. Too often not enough details are given in papers about the experimental design, methods and results. Our philosophy is that other researchers developing new (improved) ice phenology algorithms should be able to reproduce our experiment and compare results from their approach with the ones we present in our tables.

Page-by-page comments

1. Page 2/Line 30 (2/30): I suggest '*in situ* observations of lake and river ice'.

→ We changed it.

2. 3/13: I suggest using 'shrinkage' instead of 'diminishing trend'.

→ Changed to reduction.

3. 3/19: 'Obscurity' is incorrect. The correct word is 'obscuration'. What is obscuring the lakes besides cloud cover? Darkness? Perhaps you want to say 'obscuration by darkness and extensive cloud cover'.

→ We changed obscuration by darkness

4. 3/22: GSL needs to be spelled out in full as GSL has not been used so far in the main body of the text.

→ We added Great Slave Lake (GSL) here

5. 3/24: I don't think it is necessary to explain why the QuikSAT mission ended. Thus, delete 'due to antenna spin rate degradation'.

→ Done.

6. 3/29: I recommend deleting 'one of the two lakes in this study'. This will reduce the length of an already very long sentence without any loss of value.

→ Done.

7. 4/1: I recommend 'Measurements by' rather than 'Measurements from'.

→ We fixed it

8. 4/4: I recommend 'measurements for estimating' rather than 'measurements of estimating'.

→ Done.

9. 4/25: I recommend 'ice cover' rather than 'ice surface'.

→ The word 'ice cover' is fine. Fixed.

10. 5/30: I recommend not placing the lake average depths in parentheses, and instead write 'and, respectively, have surface areas of 31.3 x 10^3 km^2 and 28.6 x 10^3 km^2, and average depths of 76 m and 88 m (references)'.

→ Done

11. 6/1: The Arctic Circle does not influence weather and climate. It is not a boundary between climate zones.

→ Revised.

12. 6/5: The seasons need to be defined in the text. They are defined in Table 2, but it would be useful to do it in the text too.

→ We modified the sentence of "between -25.4 °C and -20.6 °C for winter (DJF) and from 10.0 °C to 12.1 °C for summer (JJA)"

13. 6/10-11: I recommend 'and therefore the GSL open-water period is about four to six weeks longer than it is at GBL'.

→ Done.

14. 6/21: Ascribing temperature differences between GBL and GSL to the latitude difference is as erroneous as invoking the Arctic Circle to explain temperature differences.

→ Removed reference related to Arctic Circle

15. 7/7: I suggest writing 'and the along-track and cross-track sampling interval of each channel'.

→ Done.

16. 7/18-20: The sentence beginning 'The sampling intervals …' is repetitive (see line 7) and can be deleted.

→ We kept this sentence to justify the reason for the 10 km grid spacing of the linear interpolation.

17. 7/20-21: I suggest 'except for 89 GHz, for which we chose a 5 km grid spacing.'

→ Changed.

18. 8/6: Is it necessary to refer to 'polar darkness'? It is simply darkness. See also 8/29.

→ We prefer to keep polar darkness.

19. 8/7: Has 'SIR' been defined in full earlier in the paper?

→ Added Scatterometer Image Reconstruction (SIR).

20. 8/10: I would prefer to see '24 km and 4 km' rather than omitting the unit after 24.

→ The unit of 'km' is included

21. 8/14-15. The 4 km IMS product was used for comparison with what? With your products? I think it should be made clear.

→ "with AMSR-E derived ice phenology events" after comparison was inserted.

22. 8/23: Are the lake ice fraction values 1 and 0 actually tenths, i.e., 1/10 and zero tenths?

→ Yes. Ice fraction value in tenths ranges from 0 (open water) to 10 (complete ice cover). We provided a description at the beginning of the paragraph.

23. 9/4-5. I suggest 'through ice seasons required the seasonal evolution of horizontally and vertically polarized Tb at different frequencies be examined first.'

→ Changed as suggested.

24. 9/8: It's not necessary to refer to 'from nearby meteorological stations' as those stations are described in Section 4.1.2. Instead, say 'from the meteorological stations'.

→ We changed it.

25. 9/14-17: The sentence beginning 'The bottom panel of…' basically repeats the figure caption and can thus be deleted.

→ Deleted

26. 9/25: I recommend 'increase' instead of 'augment'. Likewise, 'increase' instead of 'augmentation' in 9/27.

→ We searched for the word 'augment' in our paper and could not find it. We therefore assume that the word 'increase' is the correct word.

27. 10/3-5: The sentence beginning 'An augmentation in Tb …' is repetition – see 4/23-26

→ Again, in our paper we used the word 'An increase…' not 'An augmentation…'. If that was the case then it has been changed.

28. 10/7-8: The three references are inappropriate, as those studies were not concerned with Tb.

→ (Duguay et al., 2003) was removed and replaced with 'Figure 2'.

→ However, other two references (Chang et al., 1997; Kang et al., 2010) do present contents related to T_B hence we have chosen to keep them.

29. 10/14: I recommend 'exceed' instead of 'surpass'.

→ Changed

30. 10/17: Isn't there a primary reference that can be used instead of Jeffries et al.? The latter is a review paper and thus a secondary reference.

→ We would like to keep Jeffries et al., 2005b because his first paper is more related to lake ice growth and decay by using a lake ice model, and not related to brightness temperature observations from space.

31. 10/18: Besides not seeing the relevance of uniform internal structure and surface roughness, I don't think I can agree that the internal structure becomes uniform during melting. For example, candling due to absorbtion of solar radiation along congelation ice crystal boundaries creates a very non-uniform internal structure.

→ We removed this section accordingly.

32. 10/21-22: Do you mean to indicate that wind-roughened melt ponds are removed or do you mean to indicate that wind-roughened melt ponds are present?

→ We removed this section in accordance with Reviewer #1's main comments.

33. 12/19: I recommend 'ice-free season from those of later days'.

→ We replaced 'to' with 'from' as suggested.

34. 14/9: I recommend 'due to the fact that water depths in the confidence region'.

→ Changed

35. 14/10-11: I recommend 'between 20 m and 80 m in GSL; GBL therefore takes longer to lose its heat.'

→ Changed

36. 14/19: Instead of 'It must be bear in mind' I suggest 'One should bear in mind'.

→ Changed

37. 14/21: Delete 'therefore'.

→ Removed

38. 14/28: Another reference to latitude as the explanation for temperature difference. Why not omit latitude and simply note that the MO differences between the two lakes are due to spring air temperature differences?

→ We modified the sentence "… be explained due to spring air temperature differences (Table 2)."

39. 15/21: Delete 'spatially'.

→ Deleted

40. 16/10-11. It is probably not necessary to refer to river water melting both the bottom and sides of the ice. It is probably sufficient to refer only to the influence of the inflowing Slave River.

→ We agree. Changed

41. 16/31: I don't understand 'methods' in 'methods and satellite sensors'. Method and approach are practically synonymous. Do you mean field/in situ methods or field/in situ observations?

→ 'Methods' include comparison from pixel-by-pixel to lake-wide while satellite sensors indicate different products by different satellite sensors.

→ "….approaches and with different satellite sensors whenever possible, as to provide at least a qualitative assessment of the level of agreement with existing products" was added.

42. 17/1: I suggest 'level of agreement with existing products'.

→ We substituted ' 'between' for 'with'.

43. 17/3: I suggest 'This is a topic that merits investigation in a follow-up study'.

→ We replaced it.

44. 17/16: By 'wind-roughened cracks' do you mean 'wind-roughened water in cracks'?

→ Yes, changed.

45. 17/20: I suggest 'ice-covered lake surface, and not as much by'.

→ We modified it

46. 17/31: I suggest 'extensive cloud cover during this period'.

→ We replaced it in the sentence

47. 18/8: I suggest 'are also quite similar between'.

→ Changed

48. 18/12: I suggest 'phenology parameter among products examined.' Delete 'herein' too.

→ We modified the original sentence as "consistent ice phenology variable across products examined"

49. 18/15: I suggest 'on average from IMS'.

→ Changed

50. 18/18: I suggest 'AMSR-E suffers from land contamination'.

→ We replaced 'AMSR-E has a harder time due to land contamination' with 'AMSR-E suffers from land contamination'

51. 18/20: AMSR-E IDCp estimates are slightly shorter than what? Those available in IMS?

→ Replaced sentence by 'AMSR-E ICDp estimates are slightly shorter for GBL and

longer for GSL than IMS (Table 8).'

52. 18/21-22: I don't understand the meaning of the sentence 'Since ICDp is calculated from ice-on to ice-off dates such differences are possible."

→ We changed the sentence as "Since ICDp is calculated from ice-on to ice-off dates such differences between the two products are possible. Following sentences 'As indicated earlier…' explained these reason of different estimates for ICDp.

53. 18/26: I suggest that the comparison is less useful or less meaningful.

→ We would like to keep the original sentence.

54. 18/28: I suggest 'with AMSR-E compared to those determined'.

→ Changed

55. 19/5: I suggest 'that CIS is a weekly product'.

→ Changed

56. 19/6: Rather than use 'may' can't you be more definite and say that the differences are attributed to the temporal resolution?

→ Probably 'Yes' but some of the differences between estimates can be related to the type of sensors, frequency, and spatial resolution. Thus, we use 'may' for this reason.

57. 19/25: As noted earlier, I don't think latitude is a major factor.

→ The spatial patterns of ice phenology events change from southern to northern area (or opposite) in Figures 4-5. We would like to mention 'latitudinal position' in this part.

→ We indicated 'spring and summer temperature (for break-up)' in this part.

58. 29, Figure 1. What do the arrows indicate? River flow direction? Need to add a note to the figure caption. Also, I would like to see the sampling site dimensions given in kilometers as well as seconds.

→ "Arrows indicate river flow direction" was inserted.
→ 9.48 km × 9.48 km was added to the Figure caption.