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Interactive comment on "Analyses of Peace River SWIPS data and its implications for the roles played by frazil ice and in situ anchor ice growth in a freezing river" *by* John R. Marko and David R. Topham

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#General comments

This manuscript examined suspended frazil ice and riverbed anchor ice growth in the shallow river based on the acoustic observation. The notable point of this manuscript is that the results and discussions were mainly based on field measurements. Thus, this manuscript is important to understand river ice system. The author compared the measured and modeled frazil ice volume, and showed that the former was quite smaller than the latter. This gap was explained by the latent heat of in-situ reverbed anchor ice growth, which is ignored by the river ice model. The author also proposed the riverbed and underwater situations for single- and multi-peak frazil growth intervals. These are reasonable qualitatively. Additional quantitative discussions are expected to well understand the winter river ice condition.

I have major comments listed below.

1) For single peak frazil growth intervals, the large difference in measured and modeled value of frazil ice volume was shown. As the author suggested, in-situ riverbed anchor ice growth can be a factor of the difference because the river model ignored it. Did the volume of anchor ice growth on the riverbed reach to the level to explain the gap between measured and modeled frazil ice volume with 1 order of the magnitude quantitatively? Does the model overestimate suspended frazil ice volume in the case of lack of in-situ riverbed anchor ice growth? I would like to see more discussion.

2) The author showed that the river ice model overestimate suspended frazil ice volume. The results and discussions were based on the field data during single peak frazil growth intervals. On the other hand, these cases are not suitable to calibrate the model because of the presence of riverbed anchor ice. Are there some frazil ice growth events without the presence of riverbed anchor ice? If the model is able to estimate suspended frazil ice volume in such cases, anchor ice growth becomes to be a great factor for the model simulation.

3) The author presumed riverbed and underwater situations for single- and multi-peak frazil growth intervals. These situations are consistent with measured variations of frazil ice volume during these intervals. The author suggested that the air temperature is the key factor to induce those two situations. The multi-peak frazil events were induced during the periods of cooler air temperatures. According to the discussion of section 3.2.2, accumulated anchor ice layer became thicker during higher temperature periods. However, the heat loss from the river to the atmosphere becomes larger at lower air temperatures under same wind conditions, enhancing frazil ice and anchor ice growth. I would like to see more discussion on this point.

#Specific comments

P. 1, L. 15 – 17: “A simple physical model . . . .. river ice volume and mass.” I agree with your opinion. In addition to it, I would like to see quantitative discussion in the main text.

P. 4, L. 5 – 6: “Detailed analysis were confined to four of five major supercooling events,” Why did the author focus on supercooling instead of suspended frazil ice detected from echogram plots? Cooler river water is lighter than warmer water at the temperature below 4 $^{\circ}$C. Hence, frazil ice possibly appeared in the water column when supercooling was not detected on the riverbed.

P. 5, L. 30 – 32: “These runs utilized . . . .. a hydrostatic site approximately 370 km upstream of the SWIPS instrument.” Was the hydrostatic site located $\sim$370 km upstream of the SWIPS instruments site? It seems to be too far to apply the data to input the model calculation. Does the author have some comments about it?

P. 6, L. 3: “Five separate intervals of supercooling” How large was the level of supercooling? I recommend that the author add the level of supercooling at each interval in Table 1.

P. 6. L. 34 – 35: “The timings and intensities of the blockages, ... , are summarized in Fig. 3” I recommend that the author should show the situation of acoustic blockages and the air temperature at the same Figures of time series of F(t) in Figs. 2 and 5 or echogram plots in Fig. 4. Direct comparison of the timings of acoustic blockages with time evolution of F(t) or echogram plots helps us understand what the author described.

P. 7. L. 20 – 33: 1) The author pointed out critical timings such as 08:00 Jan 26, but these are difficult to be found in Fig. 4 accurately. It might be better to show such timings in Fig. 4 using some objects like as triangles.

2) The author mentioned the time evolution of “close-in” returns at the lowest end of the range scale, but it is too small to understand its vertical variation. In particular,

the author explained that suspended frazil ice disappeared from the echogram plots due to the acoustic blockage by anchor ice at ∼10:00 - ∼16:00. However, the vertical evolution of the layer close to the transducer was unclear in Fig. 4 at that timing. Additional panels to enlarge the range near the transducer and to show the timings of the acoustic blockages (as shown in Fig. 3) help us understand the situations of frazil and anchor ice growth.

3) In section 3.2.2, the author suggested that anchor ice which detached from the riverbed and moved to the river surface was detected with the acoustic instruments. Why was such detached anchor ice not detected in the case shown in Fig. 4? Did the accumulated anchor ice melt and lose the thickness?

4) In Line 27 – 28, the author described “Smaller concurrent reduction were apparent in the strengths of the longest range components o the saturated surface returns.” But, I was not able to find this situation.

P. 7, L. 36 – 38: “This pattern . . .. to completely block detection of acoustic returns from water column and surface targets.” Does anchor ice covering the transducer prevent return pulse only? Emitted pulse might be prevented by anchor ice?? This is just a comment.

P. 8, L. 19 – 20: “Pre-transition sensible heat fluxes, ... change in water temperatures measured on the ADCP instrument.” Was the heat loss from the river surface to the atmosphere calculated using atmospheric conditions such as the air temperature, humidity and wind speed? When the water temperature is at the freezing point, the change in the water temperature due to the heat loss becomes to be small. In addition, the water temperature can be changed by advection.

P. 8, L. 25 – 27: What was the heat to transform from the heat loss to the atmosphere if it was not used to form ice?

P. 10, L. 25 – 42: The discussion in this paragraph is interesting. In Line 33 – 38, particularly, the author proposed good discussion of enhancing anchor ice growth under hydrographic conditions in the Peace River. I would like to see more quantitative discussion, if it is possible. Does the total volume of suspended frazil ice and anchor ice become to be consistent with modeled value of F(t)? According to section 2, the instruments were heated. Is this a factor to suppress anchor ice growth or accumulation on the riverbed?

P. 11, L. 10 – P. 12, L. 2: How large the spatial (horizontal) scale of anchor ice on the riverbed? Was anchor ice distributed around the riverbed with uniform thickness? Is it possible that the instruments promotes/suppresses anchor ice formation and accumulation? Is the discussion described in these paragraphs able to be applied only for the case when instruments are deployed on a riverbed?

P. 14, Eq (7): Why does the heat flux depend on the air temperature only?

P. 14, L. 6 – 23: The author described the impact of river currents on the heat loss of anchor ice in P. 10, L. 28 – 38. Can the author consider this effect to evaluate the cumulative heat flux? The cumulative heat flux of 5.6 MJ/m2 calculated from Eq. (7) may not be suitable to be used as the critical value.

P. 16, L. 4 – 5: "a tendency for water level . . . ." This behavior was only found during Interval 3 in Fig. 5b. Did the author mention about Interval 3 only?

P. 16, L. 5 – 6: "Mean air temperature . . . associated with Intervals 4 and 5." The author described the air temperature for each Interval for the first time here. I recommend to add the panels of time series of the air temperature in Figs. 2 and 5.

P. 16, L. 19 – P. 17, L. 4: 1) The author suggested than the air temperature was a key factor of distinctions between single and multi-peak frazil events. Are there other possible factors such as wind speed and current speed? I think that turbulence is needed to bring lighter and cooler water down to the riverbed. If it is right, much water with lower temperature is brought from the river surface to riverbed. In the fact, single and multi-peak frazil events occurred during higher and lower temperatures, respectively. However, the relationship between such two situation and the air temperature was not explained.

2) This manuscript indicated that multi-peaked F(t) was attribute to detached anchor ice. I propose that anchor ice can detach at least one time for "hard" freezing conditions at Ta $\geq$ -15 °C. Then, the instruments can detect the resuspended anchor ice during the end of single peak event. Did the instrument show such an event in echogram plots or F(t)?

3) If anchor ice was formed around the riverbed and detached, the instruments detect resuspended anchor ice at several times. This scenario can explain the multi-peak F(t) when ice advection was taken into account. How do you think about it?

4) According to Fig. 9, the height of the instrument is a factor to separate between single- and multi-peak frazil events. Does the author have some idea to express the relationship between the instrument height and the air temperature to distinguish the two situations?

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