Anonymous Referee #3 Received and published: 29 November 2017

The authors are grateful to the referee for the constructive comments that helped to improve the manuscript substantially. Our responses to the comments are addressed point by point below.

General Comment: This paper describes investigation of the color of melt pond on the Arctic sea ice simulated by the radiative transfer model and validation using field observations. Such sensing and analyzing melt pond may become increasingly important for detecting progress of warming in the Arctic Ocean. Therefore, I recommend this paper for publication. However, I have a couple of major and minor comments that should be considered.

Major comment 1): In section 3.1, the authors mention the effects of melt depth and underlying ice thickness (P6. L18 – P7. L5). In addition, the effects of albedo and color of melt pond are also considered. The authors describe the pond color depends on underlying ice thickness and the possibility of estimation of ice thickness from the pond color. Basically, the pond color on first-year ice (FYI) containing brine and sea water indicates various gray depending on pond depth. The pond color on multi-year ice (MYI) displays green and blue. Thus the pond color also depends on underlying ice types (FYI or MYI). I recommend to add a description about the effect of ice type difference for same ice thickness. This explanation is expected to make the validity of this manuscript increase.
Reply: We added new descriptions on the effect of ice type on pond color in section 3.1 as "Basically, melt ponds on FYI in Arctic are shallow and flat, resulting in various gray color tones, while MYI melt ponds are always deep and narrow, displaying green and blue (Polashenski et al., 2012; Webster et al., 2015). These agree well with the variations in Fig. 4f".

Major comment 2): I agree the result of the comparisons with field observations described in section 3.5. However, the description of the quantitative measurements for pond color by Istomina et al. (2016) is incomplete. Fog appears frequently during summer and observation of pond color seem to be affected by fog. The authors should mention the influence of fog during summer.
Reply: We agree with reviewer. The fog will give impact on the pond color, especially if one took the photos from a distance, e.g. from helicopter or something like that. In Istomina et al. (2016), "fog indeed happened during the field work, but the hand-held camera was very close to the measured ponds and the work was stopped for heavy fog conditions", so the influence of fog on the obtained pond color was limited in this study.

We have added a detailed description on how the pond color was photographed during field investigations in the revised manuscript.

Major comment 3): According to Fig. 11, a good agreement can be found for thin ice with ice thickness < 1 m (P12. L19-L20). I would like to suggest that the color-retrieval method using a RTM is useful to estimate thin ice thickness because sea ice thickness has been declined in recent years. This is not discussed in a convincing way. In order to understand the argumentations given in the manuscript, I recommend to add discussion about when and where the color-retrieval method is useful. I think the valid area and period of the color-retrieval method are mainly ice edge and in late-summer, respectively.

Reply: Thank you for this very good comment. A new paragraph was now added to the end of section 4.2 to tell the limitations and applicability of the color-retrieval method. It mainly includes:

(1) This method is valid for thin ice with thickness less than 1 m, and when the melt ponds on top of ice are open or just covered by very thin ice. Frozen melt ponds with a snow or thick ice cover, having an obviously different appearance from open ponds, are excluded from this method.

(2) Overcast sky conditions are preferable for this method. They are prevailing although not always present during summer in Arctic.

(3) It is still difficult for the satellite instruments to detect melt-pond color because of the small spatial scale of melt ponds. In contrast, hand-held photography, ship-borne photography, and airborne photography are very effective ways to get the small-scale information on ice surface and provide a basis for ice thickness retrievals. Especially, with unmanned aerial vehicles (UAVs) equipped with a digital camera it is easy to observe sea ice surface features, including melt-pond color, at a floe scale.

Major comment 4): The manuscript describes that the result shown in Fig. 11 is still encouraging (P13. L1-L5). However, it is difficult to agree a new way of determining the sea-ice thickness. To clarity the validity of the color-retrieval method using RMT, I recommend to redraw plots of the ice thickness less than 1 m and more than 1 m separately in Fig. 11b. Adding the correlation coefficients, significance levels, and root mean square errors in Fig. 11 is also recommended.

Reply: Revised accordingly. We have improved the retrieve model and the results showed some improvement for thin ice thickness detection. A subplot for H_i < 1 m was also presented and all necessary statistical parameters were included.

Please check our reply to the last comment of Referee #2 for details.

Minor comments:

1) P2-L1: Studies on melt ponds area more than three aspects. For example, the studies using synthetic aperture radar and passive microwave sensor should be included. There are not many papers about remote sensing of melt pond by satellite. Recently Tanaka et al. (2016) reported estimation of melt pond fraction using satellite microwave radiometer. I recommend to cite their paper in this section. Tanaka, Y., K. Tateyama, T. Kameda, and J. K. Hutchings (2016), Estimation of melt pond fraction over high concentration Arctic sea ice using AMSR-E passive microwave data, J. Geophys. Res. Oceans, 121, doi:10.1002/2016JC011876.

Reply: Thanks for your recommendation. Satellite remote sensing on melt pond has been included in the three aspects we stated on P2. And we now added the new reference there.

2) P3-L14: RTM was investigated the dependence of apparent optical properties (AOPs), particularly albedo and transmittance, on sky conditions, pond depth, ice thickness, and the inherent optical properties (IOPs) of ice and water (Lu et al., 2016). That is worth mentioning as well. For example, it would be essential to show about the broadband albedo were higher

on overcast days than on clear days by 0.01 in August.

Reply: The AOPs of melt ponds have been investigated thoroughly in Lu et al. (2016), and therefore were not the subjective of the present study. The color of melt pond is the focus here rather than the surface albedo.

References

Istomina, L., Melsheimer, C., Huntemann, M., Nicolaus, M. and Heygster, G. 2016. Retrieval of sea ice thickness during melt season from in situ, airborne and satellite imagery, IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Beijing, 7678–7681, doi: 10.1109/IGARSS.2016.7731002.

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Webster, M. A., Rigor, I. G., Perovich, D. K., Richter-Menge, J. A., Polashenski, C. M. and Light, B.: Seasonal evolution of melt ponds on Arctic sea ice, J. Geophys. Res. Oceans, 120, doi:10.1002/2015JC011030, 2015.