Anonymous Referee #1 Received and published: 7 September 2017

The authors are grateful to the referee for the constructive comments and additional grammar corrections. They have been helpful to improve the manuscript significantly. Our responses are addressed point to point hereafter.

This manuscript presents analysis of the spectral properties of shortwave radiation backscattered from melt ponds found on Arctic sea ice during summer. The information presented is well organized, easily readable, and clear. The subject should be of interest to readers. I have only a few minor comments, mostly technical in nature.

p. 2 line 33 photo in Fig 1 shows various evolutionary stages of ponds? not sure there is 'evolution' shown in this image. Rather, this seems to me to be a fair representation of the variety of melt pond colors often seen in a particular view, however, I see no reason to infer this field represents time-dependent changes.

Reply: Indeed, the "evolutionary" is not very accurate. We revised this sentence to "The photograph in Fig. 1 reveals the large variety in melt-pond appearances even on the same ice floe."

p. 5 line 7 "two-dimensional representation works"– would be helpful to add a bit more information here– does the 2D representation completely describe the light field? Better to say that than 'works'.

Reply: Corrected accordingly. We revised this sentence to "These coordinates are dependent, z = 1 - x - y, and as illustrated in Fig. 2b this two-dimensional presentation can determine the given color (Hunt, 2004)".

p.10 line 12 "optically isotropic" is not the same as "isotropic scattering" line 14 same question line 16 pond water 'clear with regard to its optical properties'? not at long wavelengths!

Reply: We revised the terms in lines 12 and 14 into "isotropic scattering". It is exactly what we want to express there. The sentence in line 16 was revised to "it is assumed here that melt pond water is clean and scattering can be neglected (LU16)".

p. 10 line 25 subjects'

Reply: Corrected accordingly. The sentence was revised to "These functions have been determined through a series of experiments that aimed to judge colors while looking through a hole with a 2° field of view".

p. 14 line 2 superliner? not sure 'superliner' means

Reply: The description was not correct in the original manuscript. It should be "nonlinear".

p. 14 line 7 -9 I expect the reason that agreement is better for thin ice is not necessarily associated with ice topography and horizontal homogeneity assumptions of the model, but rather that thinner ice has less optical thickness. With dark ocean beneath, the thinner domain shows better discrimination as light at some wavelengths simply doesn't get backscattered, and that wavelength cutoff varies quickly with optical thickness.

Reply: We agree with reviewer. We added such interpretation in the revised manuscript at P13 "Another possible explanation comes from ice thickness since thin ice passes through more light than thick ice. With dark ocean beneath, the thinner domain shows a better discrimination as light at some wavelengths simply does not get backscattered, and that wavelength cutoff varies quickly with ice thickness" as explaining the figure.

At P15 "The latter is partly because that the plane-parallel assumption agrees more closely with ponds on flat sea ice than on rough ice, and also possibly due to the higher transparency of thin ice than thick ice" in the conclusion.

Fig 2 relatively little information content here

Reply: The original Figure 2 (Schematic graph of the radiative transfer model) was removed accordingly. The model was explained by text in P3.

Fig 4 why does pure bubble-free ice have higher absorption than sea ice? Sea water really has higher absorption than ice? These relative values surprise me, so I think they merit some comment in the text.

Reply: The absorption coefficients employed in the study came from different references. Data of the absorption coefficient of water came from Smith and Baker (1981). Data of the absorption coefficient of pure ice came from Grenfell and Perovich (1981) (> 400 nm) and Warren (1984) (< 400 nm). According to these data, the absorption coefficient of water is a little higher than that of pure ice in the 560-780 nm band, but lower than that of pure ice in the 380-560 nm band.

The absorption coefficient of sea ice is a weighted-average of that of water and pure ice according to Perovich (1996), its values are closer to pure ice than to seawater because of the large volume fraction of pure ice. Sometimes, the absorption coefficient of sea ice is also lower than that of pure ice and seawater, especially as wavelength greater than 560 nm in the figure. This happens only if there are lots of gas bubbles and little brine pockets contained in sea ice, and the absorption by gas bubbles can be ignored but their volume fraction cannot be neglected.

We added the new references into the figure capital as "Figure 3: Absorption coefficients of clean seawater, pure bubble-free ice and sea ice in the visible band. The water data are from Smith and Baker (1981). The pure ice data are from Grenfell and Perovich (1981) and Warren (1984). The $k_{\lambda,i}$ value was calculated from $k_{\lambda,i} = \nu_{pi}k_{\lambda,pi} + \nu_{bp}k_{\lambda,w}$, based on the volume fractions $\nu_{pi} \geqslant 60\%$ and $\nu_{bp} \leqslant 20\%$ ($\nu_{pi} + \nu_{bp} \leqslant 100\%$) from field observations of summer Arctic sea ice (Huang et al., 2013)".

And we also added comments in P6 as "Note that $k_{\lambda,w}$ is lower than $k_{\lambda,pi}$ for $\lambda < 560$ nm, and higher than $k_{\lambda,pi}$ as $\lambda > 560$ nm. The weighted average $k_{\lambda,i}$ varies closer to $k_{\lambda,pi}$ than to $k_{\lambda,w}$ because of the large volume fraction of pure ice, but sometimes it is also lower than both $k_{\lambda,pi}$ and $k_{\lambda,w}$ especially for $\lambda > 560$ nm (Fig. 3). This happens only if there are lots of gas bubbles and little brine pockets contained in sea ice, and the absorption by gas bubbles is limited but their volume fraction cannot be neglected".

References

Grenfell, T.C., and D.K. Perovich. 1981. Radiation absorption coefficients of polycrystalline ice from 400–1400 nm. Journal of Geophysical Research, 86: 7447–7450.

Hunt R.G.W. 2004. The reproduction of colour, 6th ed. John Wiley & Sons, pp. 844.

Perovich, D. K. 1996. The optical properties of sea-ice. Cold Reg. Res. and Eng. Lab. (CRREL) Report 96-1, 585 Hanover, NH.

Smith, R.C., and K.S. Baker. 1981. Optical properties of the clearest natural waters (200–800 nm). Applied Optics, 20: 177–184.

Warren, S.G. 1984. Optical constants of ice from the ultraviolet to the microwave. Applied Optics, 23, 1206-1225.