The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-184-RC2, 2020

The Cryosphere
Discussions
Open Access
EGU

Interactive comment on "New insights into radiative transfer in sea ice derived from autonomous ice internal measurements" *by* Christian Katlein et al.

Anonymous Referee #2

Received and published: 2 October 2020

This manuscript presents an interesting and potentially very useful new design for measuring the light field within sea ice. Making use of relatively inexpensive light sensors, the authors sacrifice some degree of accuracy in the measurements for the ability to have many, closely spaced instruments on the light string, which can be left behind after deployment. The low cost and ease of deployment will also allow for installation of the strings at many locations, similarly to the thermistor strings used as inexpensive mass balance buoys.

The concept is well presented and the first results are analyzed and interpreted in a way that shows the instrument's strengths and weaknesses. I feel it warrants publication in

Printer-friendly version

Discussion paper

The Cryosphere. The user community would likely benefit from a supplement that gives more technical details of the design.

One of the results the authors present that is important for the ability to use the side-looking irradiance measurements in more traditional applications is that, at least with diffuse incidence, the sideward looking irradiance is proportional to the scalar irradiance, a very useful quantity for biology in the ice and ocean. This result is relied upon as a justification for the unusual orientation of the irradiance sensors on the string. While it may well be an accurate and useful result, I felt the presentation and examination of the modelling this result is based on is the weakest part of the paper and should be improved before final publication. If this tool becomes broadly used, this result will be widely used and cited, so it should be well founded here. Beyond that my comments below are mostly minor.

Regarding the modelling and interpretation of the model results:

1. It appears there was no attempt to run the model for different wavelengths, given that the absorption coefficient is fixed. I feel it would be worth confirming that the factor-of-four difference to spherical irradiance holds at other wavelengths

2. How were the absorption and scattering coefficients and asymmetry parameter (a/b/g in §2.5) chosen? No references or reasons are given for the chosen values. Based on the estimates from Light et al (2008, 10.1029/2006JC003977), b=250 m-1 seems low for the surface scattering layer (SSL), though b=25 m-1 is in their range for interior ice. Warren et al (2006, 10.1364/AO.45.005320) give much lower values of a for pure ice. Is a=0.15 based on measurements of sea ice? Finally, g=0.9 is very low according to Light et al, who argued that the value they used, 0.94, "is probably too low for the majority of actual g values appropriate for sea ice."

3. The model has isotropic downwelling radiance above the ice, which is a reasonable approximation under thick clouds, which admittedly describes the high Arctic most of the summer. Still, it would be useful to see if and at what depths this relationship holds

Printer-friendly version

Discussion paper

with a direct beam, something which will be azimuthally dependent and potentially spectrally dependent.

4. Scattering obviously dominates in the SSL, so it might not matter, but was the density used to account for the fact that the air in the SSL reduces the absorption since only 40-50% of the path is ice?

5. Showing some comparisons of the modelled normalized irradiance and extinction coefficient with the observed values would give readers more confidence in relying on the model result giving the proportionality between sideward and scalar irradiance.

Other comments:

6. Line 77: Was the transparent heat shrink checked to make sure it was spectrally neutral, or could it have altered the response curves shown in Figure 2?

7. Line 79: 48 sensors spaced 5 cm apart gives a total chain length (from first sensor to the last) of 235 cm.

8. Line 95: Presumably one of the 'eight's should be 'six'.

9. Line 155: I would write 'channel' after 'clear' since 'in the clear' is an expression.

10. While the boundary effects at the bottom of the ice are explained in section 3.1, the increase in irradiance between 0.2 and 0.3 m, just below the SSL, is not mentioned. It should at least be pointed out and possible reasons for it discussed. Is it an effect of the hole, or are the lower sensors seeing more of a nearby bare area or pond? It could also be a real effect of the boundary. The light will refract on entering the ice from the air in the SSL, meaning it will wind up being more downward directed just below the surface, with very little light travelling nearly horizontally (since that would be reflected at the ice surface), so perhaps a side view a few cm below the air(SSL)-ice boundary is actually darker than after some scattering in the ice. I'm not sure you can come with a definitive answer for why the measured radiance increases in that layer, but it shouldn't be ignored.

11. Line 195: Figure 5 doesn't show any data after the 14 September snowfall, so it is illustrating exponential decay within the SSL.

12. The paragraph starting at line 215 should address why the clear channel has lower bulk extinction than any of the others, rather than being between the R and the G/B channels.

13. I would re-write line 225-226 to read 'with attenuation coefficients for the clear channel rising from 0.8 m-1 to 1.0 m-1 and for the red from 1.1 m-1 to 1.3 m-1.'

14. Figure 3 is not referenced in the text.

15. Figure 4: I would specify in the caption that it is the natural logarithm of sensor count that is plotted.

16. I think Figure 6 would be more readable with a logarithmic scale on the color axis, or separate color bars put together to allow seeing the variation within the ice. The inclusion of Figure 7 allows for seeing details at the surface.

17. Since the focus of Figure 11 is the colour of the light, it might work better to use a constant brightness. When I look at it, on screen or paper, the colour information is largely drowned out by the brightness variations.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-184, 2020.