

Replies on the interactive comments on

“Mapping radiation transfer through sea ice using a remotely operated vehicle (ROV)”

by M. Nicolaus and C. Katlein

General comments to all reviewers

First of all, we would like all four anonymous reviewers for their positive and constructive comments on our manuscript. We highly appreciate the work they put into revising our manuscript. Please find our replies to all reviewer comments below. In general, we agree to the main critics that the manuscript reads in parts too much like a field report with too many details and that it does not become clear enough that we present a mostly technical manuscript. The focus of the manuscript is indeed the description of advances in under-ice measurements of solar radiation through the combination of ROV technology and spectral radiometers. Both components have made significant technical progress during the last years that allows this kind of measurements. In a revised version of the manuscript, we will put more focus on these aspects. In order to do so, we will modify the following (major) aspects, as well as those (minor) aspects listed with respect to each reviewer comment below.

- The abstract will more focus on the technical aspects, highlighting the advances through the combination of ROV and spectral radiation measurements. We will highlight the areal coverage as well as the experiences from this study in order to allow collecting efficiently large data sets, how to process and analyze them and give a short outlook on further developments needed.
- The introduction will also cover the aspect of heat fluxes and long-wave radiation, which are missing in the current version. Also advances in ROV technology are not mentioned in the current version of the manuscript.
- The measurement section will be shortened by details about the cruise, which are less important for the methodology. Those details become more important for following analyses, when results need to be put into perspective with ice conditions etc.
- It is obviously right, that the symbols used for different variables are used inconsistently. This will be corrected
- Sections 2.6 (spectral data processing) will be moved before section 2.5 (additional measurements.) The data processing section will be extended by comments on pitch and roll issues and highlight the improvements that are made compared to data processing in Nicolaus et al. (2010, CRST).
- Sections 3.2 (transmission through sea ice) and 3.3 (repeated transects) will be merged into one section in order to distil the findings on data quality and measurement progress.
- The discussion will be shortened by the (incomplete) analyses of the data set with respect to the role of FYI and MYI for light transmission. Now, we are able to include a new reference to more advanced analyses of the presented data set focusing on this aspect (Nicolaus et al., GRL accepted).
- According to the abstract, also the conclusions will be edited to highlight the technical advances.

Anonymous Referee #2

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General comments:

This paper describes measurements of spectral irradiance and radiance that has been transmitted through Arctic sea ice and seawater to a depth of a remotely operated vehicle (ROV). The writing is clear, but very sloppy (see specific comments). The data set collected is very interesting and seemingly of high quality. I was excited to see what new scientific insights could be obtained from such an unique data set. However, I am very disappointed that I cannot identify any new insights. This paper reads as a data report, and in my opinion needs significantly more data analysis and better presentation of scientific results to be considered for publication.

[Please find our general comments above. We agree that we need to be more explicit on these aspects.](#)

Specific comments:

p.3614, line 1: Solar short-wave radiation is not the definition for light.

[We will edit this phrase](#)

p.3614, line 2: shortwave radiation is only a part of the "energy transferred through ice". The way it is written in the abstract is misleading. Further, shortwave radiation transmitted through openings, such as lead and cracks, also contribute to the melting of ice and heating of the water column. Formation of ice is of course also controlled by heat transfer through the ice, but this is heat conducted from the bottom and solar radiation has no direct role in this.

[We will rephrase this section to increase clarity. We will point out that we highlight radiation transfer in the short-wave band. This is almost exclusively the visible range, and for simplicity we refer to it as light. However, we agree that for sea-ice mass balance, heat fluxes and turbulent exchange at the ice-ocean interface are of much greater importance than light transmission.](#)

p.3614, line 20: albedo and transmittance are ratios and do not reflect the amount of solar radiation reflected or transmitted.

[We will edit this phrase](#)

p.3614, line 3: "these" refer to amount and should thus be "this".

[We will edit this phrase](#)

p.3615, line 1: This sentence is clumsy. "Their" refer to "fluxes through snow and ice, but then "their" importance is linked to light penetration through bare and ponded ice.

[We will edit this phrase](#)

p.3615, line 11: Be consistent in the use of either "sea-ice" or "sea ice".

[We tried to be consistent, but will check that again. We use "sea ice" if standing alone and "sea-ice" when followed by "properties", "thickness", etc. that refer to the sea ice. This is, to our knowledge, the correct use, although it is indeed used in different ways by different authors.](#)

p.3615, line 20: The use of the term "classical spot measurements" is strange since it refers to studies where measurements were done along transects under ice (not as long as with the ROV) and vertical profiles.

[We will edit this phrase](#)

p.3616, line 7, 13: "vertical transects" and "vertical distribution": no such data is shown in this paper. Vertical data was so far used for depth correction only.

[We will discuss the possibilities of performing vertical AND horizontal transects, as one advantage of the presented use of an ROV. However, we agree that it should not be discussed in this paragraph as](#)

it is. In general, this paragraph needs to be revised in order to be more consistent with the presented material and results (advances).

p.3616, line 13: What are the "new insights"? I can find none. I am sure the data set can contain plenty of new insights, but its interpretation and presentation is way too poor.

[See general comments](#)

p.3616, line 8: Figs. 2 and 3 should come before Fig. 4 (true for the order of other figures as well). Check figure rules for Cryosphere Figure numbering is according to the logical order, which unfortunately conflicts here.

[We will edit this accordingly](#)

p.3620, line 5, 7: $I_{\{d,u\}}$ and $E_{\{d,u\}}$ are not defined clearly and not consistent with Table 2. Is "u" for upwelling radiation, or "under-ice"?

[We will correct this, see general comments](#)

p.3620, line 9: What is "SAMIP" and what is "SAM"?

[As stated in line 4-5 information about the sensors can be found in Nicolaus et al. \(2010, CRST\). SAMIP sensors contain an inclination/pressure-module recording instrument tilt and water pressure. However, we will also make this more obvious here.](#)

p.3621, line 7: No reference to find supplementary data set. Should it be called supplementary if it is not part of the submitted manuscript?

[Indeed it is a separate publication into a data archive, so we removed the word "supplemental". We add the missing reference.](#)

p.3621, section 2.6: Symbols are not consistent with those in Table 2.

[We will correct this, see general comments](#)

p.3622, line 4: the term "transflectance" is typically used for something else than radiance normalized to incident irradiance.

[See comment for reviewer #1.](#)

p.3623, section 3.1: This section does not belong in the results section.

[As stated our focus of the paper is on the method, so this section with a lot of practical knowledge gained from the on-ice ROV-operation has to be presented in the results section.](#)

p.3625, lines 3-14: Why would the light field be expected to be isotropic especially at some depth below a highly variable ice cover?

[This is indeed a good question, but so far many publications \(Frey et al. 2012, Grenfell 1991 or Roulet 1974\) assume the under ice field as isotropic, that we thought it would be important to mention it is not. We removed it here and leave this issue to an upcoming publication. See also comment for Reviewer #1.](#)

p.3629, lines 1-18: Do the analysis suggested in this section, and resubmit this valuable data set.

[As stated we think that the presentation of the method better stands for itself than being confused with highly sophisticated data analysis. The data analysis has been partly done and a part of it is currently accepted as a publication Nicolaus et al \(GRL\). See also comment for Reviewer #1.](#)