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 #1
Received and published: 17 September 2012

General comments:
In this paper, a methodology is described for measuring transmittance through sea ice along transects. Experience is reported based on several campaigns during a cruise traversing the Arctic Ocean. The background is described of the derived data set that, laudably, the authors made publicly available. The paper is well written. However, data analysis is rudimentary. While an empirical procedure is suggested (and applied) to reference irradiance data to a common level beneath the sea ice bottom, discussion is missing of radiance and irradiance corrections due to pitch and roll of the remotely operated vehicle (ROV). For what it is, this manuscript is a useful reference for future, related work, and for the data set acquired. However, data correction for pitch and roll should be discussed.

As mentioned above, we will add some comments on roll and pitch data and possible inclination correction of the data. While flying the ROV, the pilot kept the vehicle as level as possible, definitely aiming for angles under 10°. Including additional tests that we explicitly performed this year during another fieldwork, we suggest to discard data with inclination >10°. We do not think that a real correction for inclination below 10° is relevant, as changes are well below 2% (relative). Changes in fluxes would be below the accuracy of the spectrometer. We do not suggest a correction above 10° either, since this would need to include various assumptions on the light field under sea ice and the heterogeneous ice cover in the vicinity.

Specific comments:
The conclusion that the emerging light field received at the ROV is not isotropic is not supported by the data as presented. There is only a comment made in passing that this is not the case but since nothing is exact in field measurements, more elaboration is needed with regards to data analysis and errors (e.g. regarding pitch and roll).
We agree that this statement is not supported well enough through the presented data analyses. And since the focus of the manuscript should more focus on the technical aspects, we will remove this statement and its discussion. It will most likely be subject of future and more detailed analyses and publications.

It is not made clear how the empirical method (scaling measurements to a particular depth) depends on the sea ice properties above the ROV. To what extent would this need to be considered if sea ice optical properties changed along a transect? Is this an issue in the presented dataset? For example, if the distribution of radiance is affected by the presence of meltponds and holes in the ice, this would presumably affect the relationship between extinction and depth.
The applied depth-correction is a first order approximation to the 3D radiative transfer situation. Of course, sea-ice properties, geometry and topography play an important role in the extinction of irradiance. We came to the conclusion that a handling by a simple exponential model is accurate enough within the other measurement errors. Measured apparent extinction-coefficients of seawater are used for the correction and these should be representative for a few meter below the sea ice.
The data example (Fig. 7) shows how transmittance profiles smoothen with greater dive depth. As the correction is a physical water property the spatial variability does not harm the corrected energy flux, but only smoothens the contours referred to a profile recorded closer to the ice.

I suggest the term transflectance not be used to describe the ratio of radiance detected at the ROV and solar irradiance above the ice.
We know that the term transflectance has been used previously mainly within NIR-spectroscopy for the analysis of food samples, but as far as we understand this usage is outdated terminology. The term usage was suggested and discussed previously on a conference and we don't see any

overlapping usage within polar or climate research. The term is defined in analogy to reflectance, so it should be easily understandable. We have so far not found any satisfying alternative term whose meaning is as easy deducible from the common terms of transmission and reflectance.

Nomenclature seems inconsistent: are EDt and Ed,u the same thing?
Similar for IDt.
We will correct this, see general comments above.