Response to reviewer # 1

RC1: 'Comment on egusphere-2024-3819', Anonymous Referee #1, 28 Mar 2025 reply

We would like to thank reviewer #1 for taking the time to read our research article and to give us his insightful comments. We appreciate the constructive comments enabling us to improve our manuscript. Responses to the comments are given below.

This manuscript presents a novel technique for investigating in situ magnitude and shape of the radiation field within a sea ice cover. Application of a commercially available 360 deg camera, along with sophisticated radiative transfer modeling, is demonstrated to yield detailed, vertically-resolved inherent optical properties of sea ice. The topic of this manuscript is of high interest to the TC readership and the manuscript is clear and concise, with appropriately illustrative figures. I found the manuscript a pleasure to read and think it is publishable in something very close to its present form. My only comments are minor, as detailed below. I found it particularly interesting to see the skeletal layer resolved in this study.

Fig 1c: Could be a bit more clear about the camera FOV and what it is seeing. The fact that the FOV is reduced to 76 deg (water, compared to air) should be mentioned in the text, not strictly relegated to a figure caption. It's not clear from the drawing in Fig. 1c where exactly the two fish-eye lenses view, nor is it clear what the solid angle 2*pi sr refers to.

We agree that additional details on the camera's field of view and viewing direction should be explicitly included in the text. To address this, we have modified the sentence at lines 109-110 as follows:

"The Insta360 ONE low-cost omnidirectional camera (see Fig. 1c) has a diameter of 5 cm and includes two fixed-aperture ($f\#$ = 2.2) fisheye lenses."

Additionally, we have incorporated the following clarification at lines 112-116:

"When the camera is in air, each imaging sensor can capture light from a hemispherical solid angle of 2π steradians. In water, this solid angle is reduced due to a decrease in the field of view along the optical axis of each lens, from 90˚ to 76˚ (Larouche et al., 2024b). In our measurement set-up, the optical axes (aligned with the *zc* axis in the zoomed region of Fig. 1c) of both fisheye lenses are oriented 90˚ from the zenith."

167: "In ice…", would be good to be more explicit, "In sea ice…"

"In ice" was replaced by "In sea ice" as suggested.

Figure 2: lots packed in here, would be helpful to have a bit more orientation (authors have been looking at these distributions, but they are new to us readers). E.g. line 274, help me see "is apparent" by walking me through the distribution in the figure.

Commented [Ui1]: The azimuth angle is set relative to what?

Thank you for your comment. This part was added in the lines 273 – 280:

"These polar graphs show radiance angular distribution in spherical coordinates. The azimuth angle corresponds to a fixed reference on the camera, with lens #1 arbitrarily set at 90 degrees and lens #2 at 270 degrees when transforming RAW images into radiance. However, as the radiative field in sea ice is considered to be homogeneous as a function of azimuth angle, the camera is not positioned in exactly the same way for each measurement. This could have an impact in ice with very low scattering or under a melt pool, but not in the two cases studied. The zenith angle indicates where radiance comes from relative to the vertical axis. It varies from 0 (center of graph, downward direction) to 160 degrees (outer ring, upward direction) and indicates the elevation of the energy direction where 0 degrees indicates a downward direction (towards the ocean) and 180 degrees would indicate a perfectly upward direction (towards the atmosphere). The top panels (a, b and c) show radiance with the same color scale for the three channels centered at 480, 540 and 600 nm. The signal is predominantly blue in a downward direction (center of graph), followed by green and red. In the bottom panels (d, e and f), radiance is normalized to each depth, allowing us to better appreciate how its shape changes with depth. At higher elevations, the signal is much more homogeneous, whereas deeper within the sea ice, the angular distribution of radiance becomes increasingly downward. This effect is further accentuated at longer wavelengths."

245: Eqn 9 exponent is – ½ (difficult to see negative sign, but so important!)

The exponent has been rewritten to better highlight the negative sign.

305: "imply fieldwork error" how about "likely derive from large observational uncertainties"?

Thank you for your comment. We changed the sentence accordingly.

347: is "zenithal" a word?

Yes, "zenithal" is a recognized adjective, as defined in the Merriam-Webster dictionary. Given its recognition, we have opted to retain it in the manuscript.

354: "Gershun's law"

Thank you for your comment, the error has been corrected.

395: "The first two centimetres of pack ice are a special case, as they are made up of snow…" Snow or surface scattering layer?

The sampled multi-year ice was covered at that moment by 2 cm of snow. There could have been a surface scattering layer, but it was not observed in that specific case.

409: winters? Or previous summer? Multiple melt seasons? Or one previous melt season?

Thank you for your comment. In fact, we wanted to say that the ice had undergone several seasonal cycles, both expelling brine during the cold freeze-up period and draining during melt periods. It would indeed have been very interesting to explain the number of seasons the ice had survived. However, this would have required crystallographic investigations accompanied by oxygen isotope analyses. This could be the subject of a future study.

556: spectral bands centered on 480, 540, 600 (since they likely aren't strictly at those wavelengths)

Thank you for pointing out this inaccuracy, it has been corrected in the text.

563 – 564: "significantly higher light attenuation was assessed, due to both larger absorption, 0.32 – 2.11 m-1, and reduced scattering coefficients, 0.021 – 7.79 m-1," . Here "reduced scattering coefficients" is confusing—it refers to b', but it also sounds like the b' values are lower, when I don't think that's the intent. Rewrite for improved clarity.

Thank you for pointing this out. It is true that using the term "reduced" leads to ambiguity. The sentence has been modified to say simply, "more scattering".