The Cryosphere Discussions

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Comment on tc-2021-372

Anonymous Referee #1

Referee comment on "Quantifying the effects of background concentrations of crude oil pollution on sea ice albedo" by Benjamin Heikki Redmond Roche and Martin D. King, The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-372-RC1, 2022

This manuscript addresses the effects of included droplets of oil on the albedo of sea ice. The authors have assembled data on the inherent optical properties of two types of crude oil and used these values, along with information about the optical properties of three types of sea ice (multiyear, first-year, melting) to assess the effects of included droplets of oil on the spectral albedo of the ice. The authors assess these effects as functions of loading, ice type, oil droplet size, background carbon loading, and ice thickness.

The text is very easy to read as the writing is crisp and organized. However, I have concerns about the substance of this manuscript and its conclusions. This manuscript describes a carefully executed sensitivity study and I find no fault here in the mechanics of the sensitivities assessed. However, these studies offer little new physical insight or understanding. I find the title somewhat misleading, as the authors really have not quantified the climatic impact of oil pollution—that would be a much more far reaching study—likely involving a climate model. My more significant concern however is the conclusions that are sensitive to the inherent optical properties chosen for the three ice types. I don't believe that the optical descriptions given here for first-year, multiyear, and melting sea ice are realistic or representative in the context of this study. It is well established that the scattering coefficients for sea ice display significant variability, including between ice types, within a single ice column, and for the same ice type (e.g., FY, MY, melting) at different times and locations. This variability poses problems for the types of conclusions stated in this manuscript.

In fact, I'm a bit confused by the FY, MY, melting classifications. If Arctic sea ice isn't melting, it is likely snow covered. Do the authors intend for this study to treat bare, non-melting FY, MY ice? And, if the snow is implicitly included, then the dynamics of snow-oil interactions need to be accounted for. I see that snow cover is mentioned at the end of the manuscript as an uncertainty, but it's not clear that it is being accounted for in the optical properties listed in Table 1. I don't think the corresponding clean ice albedos generated from these properties are representative of ice conditions that are commonly observed in nature.

183: how do authors justify 201 layers?

200 (Eq1): What is the prime symbol for?

212: why bother modeling the atmosphere here? Seems extraneous.

299: "The oil is most absorbing at 400 nm, where ice is the least absorbing…" Perhaps this is true, but this is the cause, not a result.

313: "the effect of oil significantly decreases as wavelength increases over the region studied and the oil becomes less absorbing whilst the ice becomes more absorbing." Same as previous comment, this is a physical cause, not a result.

328: "The three types of sea ice have different unpolluted albedos: melting sea ice 0.72, first-year sea ice 0.87, and multi-year sea ice 0.94 at a wavelength of 400 nm respectively, owing to their different scattering cross sections (Perovich, 1996; Marks and King, 2014)." I think this overstates the differences between these three ice types if indeed it is intended that all are snow free.

606: "As these data shows, this decline in perennial types of sea ice renders the Arctic much more vulnerable to increased oil pollution in the region..." I don't think this conclusion is supported by this study. For example, the high scattering prevalent in the surface layers of multiyear ice, and the larger thickness of this layer in thicker ice is not accounted for in this study. Also, there is no attempt to simulate how oil droplets respond to summer freshwater flushing that is a key factor that distinguishes FY ice from MY ice.

621: "Therefore, it appears that the type of oil has the biggest effect on how responsive sea ice is to increasing mass ratios of oil as opposed to the type of sea ice and in contrast with the findings of a comparable study into the effects of mineral dust on sea ice albedo (Lamare et al., 2016)." I don't understand what this means. Is it saying that there is larger variability in oil inherent optical properties than in the optical properties of mineral dust? That may be so, but it is not a result or a conclusion.

627: "First-year and particularly melting sea ice are more responsive to oil pollution than multi-year sea ice, so these trends indicate that sea ice albedo in the Arctic may become more vulnerable to background levels of oil 630 pollution as the ice becomes progressively thinner and younger." I find this conclusion unsubstantiated, because I don't think differences in the optical properties of FY / MY ice types is treated in a realistic way here. This simplification may be well justified for the purposes of a sensitivity study such as carried out here, but I think it's a stretch to draw conclusions such as stated here from

this type of sensitivity exercise.