The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2020-362

Anonymous Referee #1

Referee comment on "Brief communication: Grease Ice in the Antarctic Marginal Ice Zone" by Felix Paul et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-362-RC1, 2021

First, this reviewer was not involved in the previous submission of this manuscript. The review record of the previous submission shows that the authors have changed the submission from a full paper to a brief communication, because of the limited scope of the manuscript. Such change is appropriate.

The shear-thinning possibility of frazil mixture reported in this study is novel, which makes this study particularly interesting.

However, there is a big question associated with the interpretation of their data: is the shear inside the viscometer linearly distributed throughout the stationary and the rotating boundaries? Furthermore, are the two boundaries really at Rs and Rv? Their Eq. (2) relies entirely on these assumptions. A relatively less but still important question: Is the frazil concentration constant in the entire shear zone, i.e. can phase separation play a role? It is known for many fluid-solid mixtures that when sheared a boundary layer may developed so that the material only shears in a narrow band. Phase separations are also common. For frazil mixtures, the reviewer remembers that years ago researchers at HSVA (Hamburgische Schiffbau-Versuchsanstalt) tried to develop an ice slurry viscometer nicknamed “Kosmoski” and found the above-mentioned situations. Maybe the present viscometer design could avoid these problems, but the authors must first verify that the kinematics inside the apparatus agrees with their assumptions: linear shear distribution from the vane tip to the wall of the apparatus, and almost uniform ice concentration. The reviewer recognizes that such verification is challenging to do in the field. Hence, the best approach is to test the performance of the viscometer using frazil mixtures grown in a lab first. The authors may start with a surrogate mixture if no access to cold rooms.

The reviewer suggests the following to move forward with the manuscript:

Decline, but strongly encourage this study to move forward, because it is interesting and relevant for the basic understanding of the initial ice cover. The authors should focus on establishing the validity of their assumptions behind Eq. (2) and the nearly uniform ice concentration in the viscometer and resubmit.

For the future submission of this work, it is suggested that:

- A schematic of the interior of the viscometer should also be given. Fig. 1-III now only has the photo of the exterior. In this schematic, all dimension including the Rs value missing in the current manuscript should be added.
- Add explanation of the 2/3 in Eq. (1).
- Add a reference "Daly SF ed. 1994. *IAHR Working Group on Thermal Regimes: report on frazil ice*. CRREL Spec. Rep. 94-23, 52pp." This report can save the authors from explaining the formation of frazil crystals. Contrary to what the authors said on line 31, frazil crystals do NOT only form in turbulent waters. However, turbulence enables "secondary" nucleation hence a rapid growth of frazil accumulation under most natural field conditions.
- In future data analysis, it would be very interesting to relate the viscosity to ice crystal size. The reviewer is also interested in knowing if the crystal size is related to their salinity, though the latter has negligible effect on viscosity.