Editor Review and Decision Letter

Manuscript: egusphere-2025-999 (Version 4)

Editor: Petra Heil

Decision: Minor Revision

Dear Noa, Isaac and co-authors

Thank you for submitting this revision of your manuscript. Unfortunately, no external reviewers were able to be secured for this round; therefore, I am providing general and detailed comments based on my own editorial review of your latest version. Please consider these points carefully before proceeding. - The manuscript presents a novel mathematical framework for examining how microbial presence (specifically EPS and metabolic byproducts) alters the fluid dynamics within sea-ice brine channels. The manuscript successfully develops a mathematical framework using the Darcy-Brinkman equations to describe fluid motion within the porous sea-ice matrix. However, to strengthen ready for publication in TC, the authors might want to consider how to bridge the gap between abstract mathematical results and observable polar phenomena.

Major comments

- Scale and Context: While the model focuses on micro-scale convection, it lacks a discussion on how these small-scale instabilities scale up. For example, could microbially-induced convection be a precursor to larger instability? Differentiation between these micro-scale processes and larger-scale features is necessary to provide proper context.
- Darcy-Brinkman Framework: The use of the Brinkman term (for viscous shear) is appropriate near the ice-water interface, but the transition to a pure Darcy flow in the interior must be justified with a dimensionless analysis of the Damköhler or Brinkman numbers.
- The manuscript currently lacks sufficient model validation against observed datasets and requires more precise terminology regarding the porous media flow. In a research paper your model must be benchmarked. This may be by comparing the model's predicted vertical nutrient profiles or salinity "desalination" rates against existing data
- While this is a mathematical study, the research impact is limited if the upper boundary condition is purely static. Please discuss how high-frequency atmospheric cooling (thermal "shocks") interacts with the microbial-induced convection.

Detailed comments - Mathematical Corrections

- Permeability (K): You rely on a functional form of $K(\phi)$. Please ensure the Kozeny-Carman constant used is specific to the columnar ice crystal structure, as recent studies suggest the standard value of 5 is insufficient for sea ice.
- Notation: In Version 4, there is a mismatch in the symbol for brine salinity between Section 2.1 and 2.3. Use a consistent S_{br} throughout.

I look forward to progressing with your response with the revised version of this manuscript.

Thank you for choosing *The Cryosphere* for your work.

Best regards,

Petra Heil, Editor, The Cryosphere, European Geosciences Union (EGU)