WG co-chairs:

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Background

The Marginal Ice Zone (MIZ) is a pivotal and dynamic frontier in the polar regions, serving as a transition boundary between the open ocean and the dense pack ice. It plays a vital role in modulating atmosphere-ocean exchanges and significantly influences the contemporary sea ice covers observed in both the Arctic and Antarctic. The MIZ is characterised by seasonal variations, governed by a complex system that couples the sea surface pressure, temperature, and winds. Our current understanding of the MIZ is characterised by very large uncertainties and unknowns. For example, we do not know the mechanism (or mechanism) for energy loss by waves by ice floe.

Understanding the MIZ is not only of scientific import but also holds substantial economic interest due to its impact on global climate change and maritime access and transportation. The delineation of the MIZ remains ambiguous, giving rise to various models proposed to define its extent and the ice floe size distribution. These range from a statistical definition based on the spatial and temporal variability of sea ice concentration, to dynamic wave-ice interaction models, and to streamline models that adhere to desirable mathematical properties. Such models are crucial to improving our understanding of the MIZ and for developing robust predictive capabilities that can inform policy and economic decisions in a changing world.

Objectives

The proposed IACS working group is committed to enhancing our comprehension of the MIZ through a diverse set of research approaches focusing on:

- **Sea Ice Physical Processes:** Investigate the essential physical dynamics of sea ice within the MIZ, encompassing the thermodynamic and mechanical underpinnings of ice formation, melting, and movement, and their sensitivity to the unique environmental conditions prevalent within the MIZ.
- **Wave-Ice Interaction:** Study the intricate interactions between oceanic waves and sea ice. Analyse how the energy from waves impacts the integrity of the ice, leading to the formation of ice floes and alterations in the melt patterns, thereby influencing the structural and spatial configuration of the MIZ.
- **Atmosphere-Ocean-Ice-Snow Feedbacks:** Examine the complex feedback loops between atmospheric conditions, ocean currents, sea ice, and snow cover and understand the coupled dynamics between the components.
- **Biogeochemical Processes:** Modelling the biogeochemical interactions within the MIZ that are crucial to understanding its role in global carbon cycles and marine ecosystems.

Deliverables

The research conducted by the working group will provide important information on the current state of the MIZ and future projections, emphasising its critical role in both the Arctic and Antarctic regions, distinct yet interconnected polar environments.

The deliverables of the IACS working group on the Marginal Ice Zone (MIZ) are designed to advance the mathematical and scientific understanding of the MIZ as well as to enhance collaboration and produce other tangible outcomes, such as a common workspace for data and model development. These deliverables will include:

- **Establish a Unified Data Set of Waves in Ice Measurements**
  Currently there are numerous measurements of waves in ice which have been made over decades using different methods (wave buoys, satellites, underwater cables etc.) and we aim to combine this into one unified data set. Such data set will clearly show changes in the waves within the MIZ over the years.
- **MIZ Wave-Ice "Models Collection"** At present, there are many different wave-ice attenuation models and there is no consensus as to which is best. Current wave-ice models need to be validated against field measurements. This validation must be performed with care and with a careful statistical analysis. The model collection will then be categorised to allow uses to choose a suitable model.

- **Establish Data Set of Bioactivity within the MIZ** Collecting bioactivity over the last decades will provide information about changes occurring in the bioactivity of the MIZ and will enable us to develop a mathematical model to describe such evolution.
- **Global Atmosphere-Ocean-Ice-Snow "Models Collection"** Going over global models involving Atmosphere-Ocean-Ice-Snow interactions (or part of them), we will create a data set that explains the differences between the models, the advantages of choosing a specific model and categorise the models. Such collection will allow us to understand the role of MIZ in current global models.

Activities
We will organise a series of activities to achieve the objectives

- **Review paper**
  We will begin with a review paper of wave processes in the marginal ice zone.
- **Virtual Sessions Organisation:** We will start our work by organizing virtual sessions that will serve as platforms to discuss individual and group work related to the MIZ, fostering dialogue and collaborative idea generation among WG members. These sessions will be instrumental in setting the foundation for our research approaches, allowing for the exchange of insights and preliminary findings. They will also establish community datasets or model repositories, as appropriate.
- **Special Session Organisation:** Organisation of special sessions at key conferences to discuss the mathematical modelling of MIZ dynamics, fostering dialogue and collaboration within the interdisciplinary scientific community.
- **Special Issue:** This special issue will consist of a collection of peer-reviewed research papers that focus on the MIZ. The purpose of this special issue is to highlight the latest developments and findings in MIZ research, fostering a deeper understanding, and facilitating further scholarly discussion.
- **Research Papers:** A series of peer-reviewed research papers detailing the advanced mathematical models of the MIZ that will be developed by working group participants, to be published in leading scientific journals.

These deliverables will underscore the contribution of the working group to the understanding of MIZ dynamics and promote the integration of mathematical methods in cryospheric research. The table below outlines the schedule for the WG:

	2024	2025	2026	2027
Jan-Jul	First virtual meeting, Finalise initial members' list	Kick-off meeting (in-person)		Special issue
Aug-Dec	1^{st} annual report	2^{nd} annual report	3^{rd} annual report	Final report

Working Group Organization and Membership:

1. Three co-chairs (Meylan, Kraitzman, Eisenman)
2. A steering committee: co-chairs + additional members; to be determined in consultation with the WG members, after initial meeting
3. Members: a number of members have expressed their willingness to contribute in response to an initial cryolist email. Additionally, we have compiled a list of other potential collaborators who bring valuable insights and experience to our research objectives

Post-approval and announcement of the working group proposal, we plan to conduct an open call for participation (e.g., through SIAM Mathematics of Planet Earth and Cryolist). This will enable us to expand our team with additional members, ensuring a broad and inclusive representation of expertise in the study of the MIZ in both the Arctic and Antarctic regions.