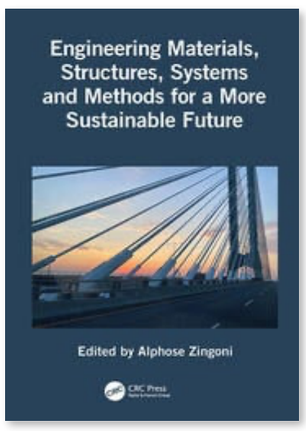

Chapter

Towards multi-fidelity models of coupled multi-X processes in sea ice within the Antarctic marginal ice zone

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ABSTRACT

The Antarctic Marginal Ice Zone (MIZ) is a dynamic and complex region where sea ice interacts with oceanic, atmospheric, and ecological processes. Accurately modeling the processes related to sea ice requires a multi-fidelity approach that can capture the coupled multi-X (scale, phase, field, ...) physical and biogeochemical processes. Traditional high-fidelity models, while precise, are computationally expensive, limiting their application for large-scale and long-term simulations. On the other hand, low-fidelity models are computationally efficient but often fail to accurately represent the intricate interactions within the MIZ. Apart from this, making time dependent observations in the MIZ is in itself a challenge. This paper presents a framework for developing multi-fidelity models, starting from high-fidelity simulations that act as input data for low-fidelity surrogate models to improve both accuracy and computational efficiency in modeling the coupled processes in the Antarctic MIZ. The approach leverages dimensionality reduction techniques to create surrogate models that bridge the gap between highly detailed small scale process models to low resolution large scale global models . By combining data-driven models with physics-based simulations, the framework captures the complex dynamics of sea ice, including thermodynamic processes, phase transition, and primary production. Initial results demonstrate the potential of this approach to provide accurate predictions with reduced computational costs. The framework is validated against available literature data from the Antarctic MIZ. This work represents a critical step towards more robust and scalable models for understanding and predicting the behavior of sea ice in polar regions, which is crucial for global climate models and ecological studies.

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