Gavin Brown Best Paper Prize
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Dispersion relations, power laws, and energy loss for waves in the marginal ice zone
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Propagation of ocean waves through the sea ice covered ocean ("waves-in-ice") has been studied for over four decades by experimentalists, modellers and theoreticians. Motivated by the dramatic changes in the world's sea ice cover over the past decade, a large community of international researchers has formed to study the phenomenon, as waves can have a destructive impact on the ice cover for up to hundreds of kilometres, thus enforcing positive feedbacks that weaken the ice. Understanding how wave energy attenuates over distance through the ice-covered ocean underpins predictions of the region of ice impacted by waves. Measurements show each frequency component of the wave spectrum attenuates exponentially at a frequency-dependent rate. The exponential rate is known as the attenuation coefficient and is the key unknown in the field of waves-in-ice. Mathematical theories are crucial to advance understanding, as the waves-in-ice region is harsh and highly dynamic, making it difficult and expensive to conduct measurements, the processes are below the resolution of most satellites, and the problem is beyond contemporary numerical limitations. The paper addresses dispersion relations for waves-in-ice, which generate attenuation rate predictions. It begins with a careful review and analysis of waves-in-ice measurements, including historical measurements and those from recent campaigns. The analysis is conducted with mathematical sophistication, not brought to bear by the experimentalists, demonstrating that the attenuation coefficient has a power-law behaviour with exponent around three.

The main body of the paper unravels the origin of the power-law behaviour, showing how it arises in many models in the regime of interest and how the exponent can be extracted. The analysis empowers the construction of models with the correct exponent. Further, the power-law behaviour is shown to be a product of the energy norm structure of the problem. The paper has had a significant impact on the waves-in-ice field and beyond. In particular, the discovery of power-law relationship has modified the approach to data analysis and theory, and set a new benchmark for theoretical contributions to numerical prediction models, such as the WAVEWATCH III third-generation spectral wave model and the CICE sea ice model. The paper was unanimously recommended for the Gavin Brown Prize by the assessors. In the words of one of the assessors: "It [...] represents a milestone in the research of wave–ice interaction. I unequivocally support this paper for the Gavin Brown Best Paper Prize."