Modelling and Data, why one cannot live without the other

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Outline

US Navy Agenda

From the Marginal Ice Zone DRI

- The Arctic and Global Prediction program is ONR's response to the Navy's need for more research into understanding the environment and expanding our predictive capabilities.
- We've been investing in new observing systems to understand what is going on in the Arctic.
- The Navy expects to operate in all the world's oceans. Because of the opening up of the Arctic during summers, the Navy anticipates that it will have to send surface vessels to the Arctic for military or other emergency purposes.

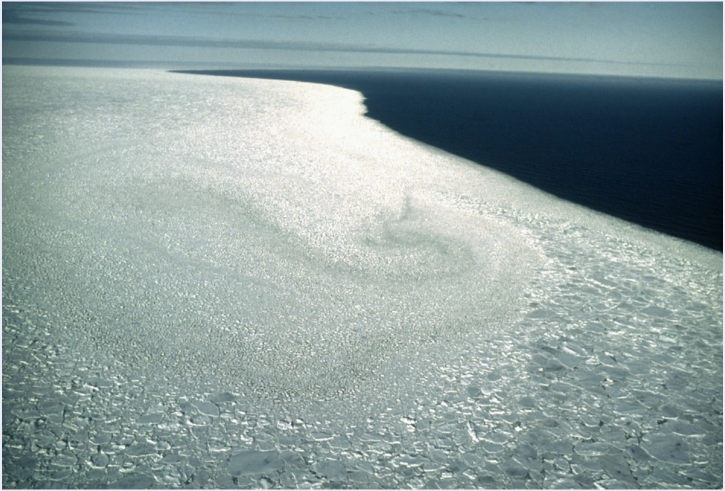

Figure: Ice Edge

Figure: Marginal Ice Zone

Figure: Break up

Figure: Break up

Wave Ice Interaction Movie

Modelling Wave Attenuation

There are two approaches to modelling wave attenuation in the MIZ

- One is based on scattering theory and solves for each ice floe using methods similar to those used to predict motion or ships or offshore oil platforms.
- The second is based on a viscous layer in which the effect of the ice is parameterised

Probably both models have a range of application. The first method is more challenging but requires less assumptions.

Measuring Wave Processes

- Polar regions are extremely demanding places to conduct research
- Many people have tried to make measurements of wave processes using satellites but unfortunately this has not proved successful.
- Best results until recently were obtained by Squire and Moore 1980.
- There has been a huge push in recent year to try to improve this situation, including recent work in the Antarctic by Kohout (Meylan) et. al. NATURE
- Modelling has proceeded without measurements

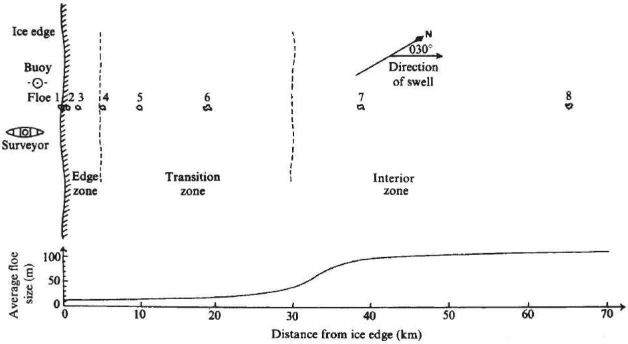

Fig. 1 Schematic diagram of attenuation experiment.

Figure: Squire & Moore 1980 Wave Attenuation Experiment

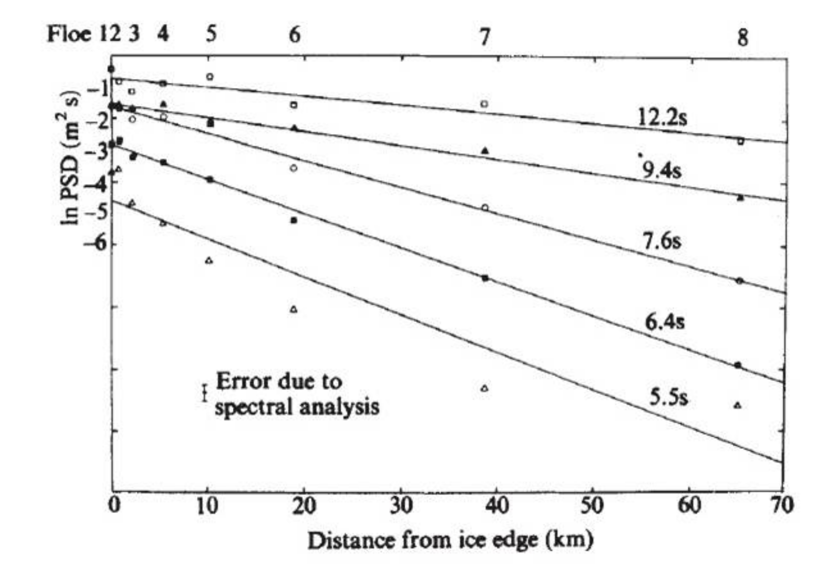

Figure: Experimental Results

SCHULZ-STELLENFLETH AND LEHNER: MEASUREMENT OF WAVES IN SEA ICE

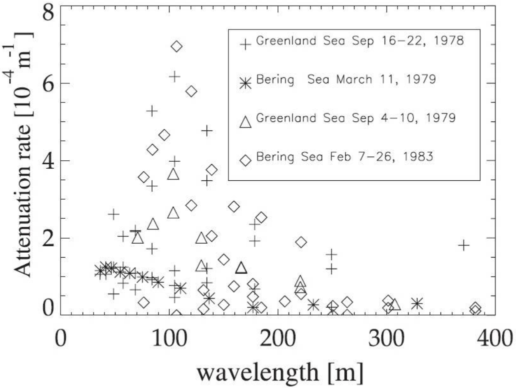

Figure 1. Attenuation rates of ocean waves damped by sea ice as reported by *Wadhams et al.* [1988] (compare equation (1)). The estimates were obtained under various ice conditions in the Greenland Sea and the Bering Sea.

Figure: Summary of Results of Wadhams et. al 1988

Measurement of Kohout et. al. 2014 NATURE

Figure: Aurora Australis

Figure: Deploying the Buoys

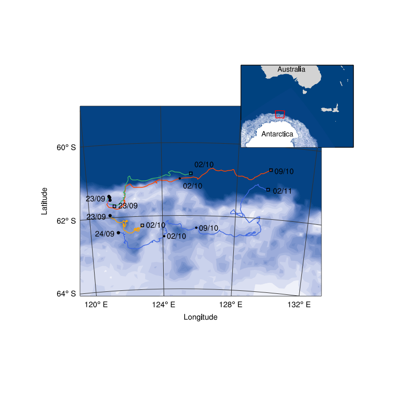

Figure: Drift of the Wave Buoys

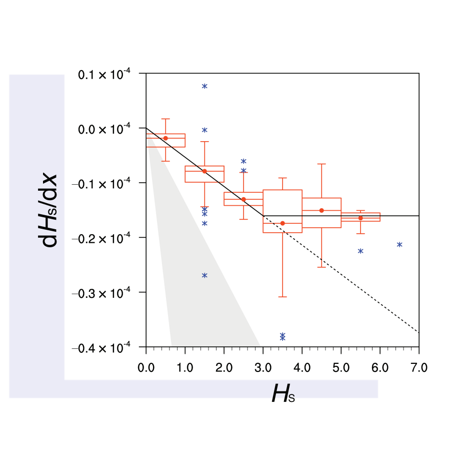

Figure: Attenuation

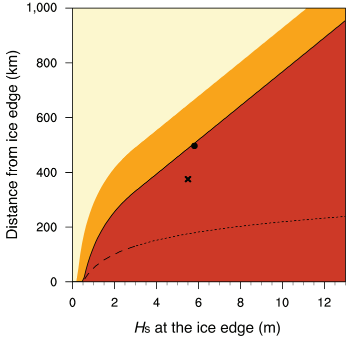

Figure: Breaking

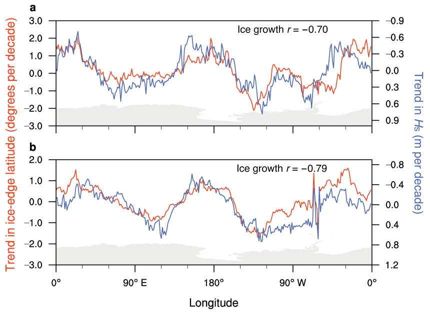

Figure: Ice Extent and Wave Height Correlations

My interpretation of the data

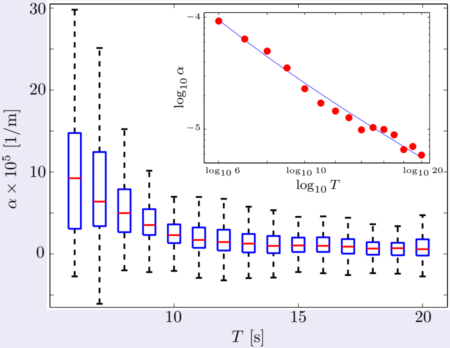

Figure: Spectral Attenuation Coefficient from Meylan et. al. 2014 GRL. Inset shows a T^{-2} fit of period.

Pancake Ice Experiments of Doble and Wadhams

- This experiment was conducted in 2000, and was very similar to that conducted by Kohout.
- An array of buoys was deployed into the advancing MIZ of the Weddell Sea.
- The buoys were deployed in new pancakes at 50-60% concentration with frazil ice between.
- Using the methods developed for the Kohout data were were able to recently analysis this data.

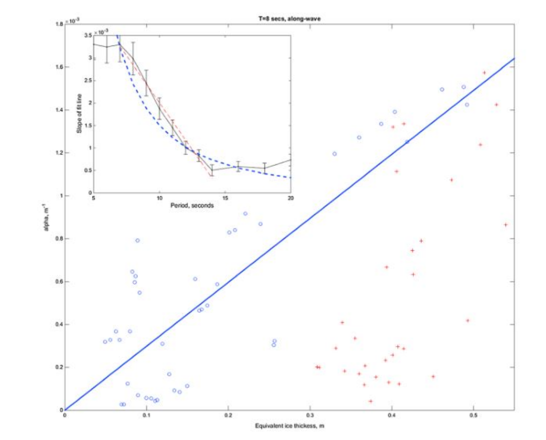

Figure: Ice Thickness versus attenuation for $T = 8$s. The inset shows the slope as a function of period from Doble, Meylan et. al. 2015 GRL

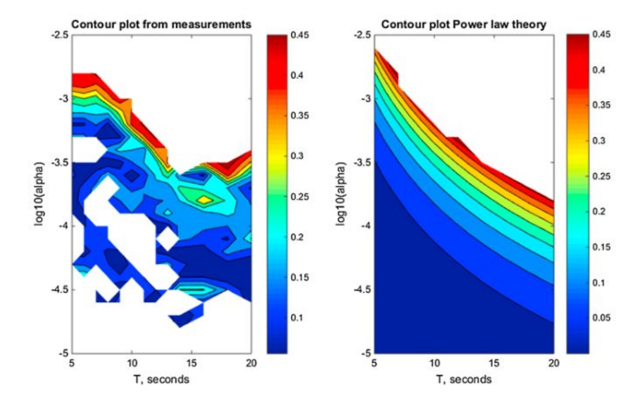

Figure: Comparison of the data and a model fit that attenuation is proportional to $0.2T^{-2.1}h$ (Doble (Meylan) et. al. 2015 GRL)

An alternative interpretation of the Data

From Li, Jingkai and Kohout, A. L. and Shen, Hayley H., Comparison of wave propagation through ice covers in calm and storm conditions, *Geophysical Research Letters, 2015*

- Apparent wave attenuation contains contributions from many source/sink terms.
- Nonlinear energy transfer offsets the ice damping in storm cases significantly.
- Frequency dependent ice attenuation works the best in explaining field data.

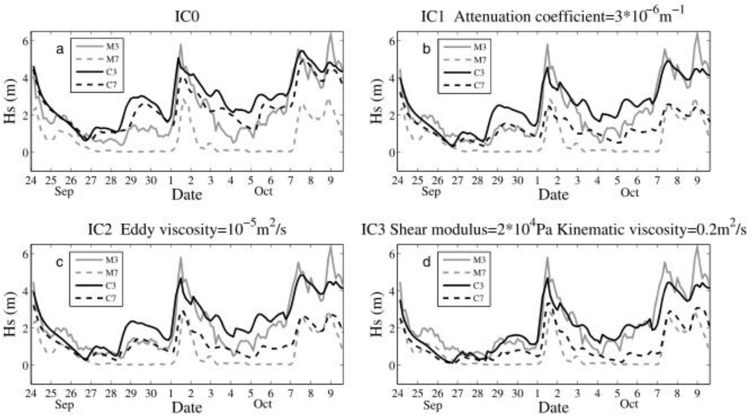

Figure 2. (a–d) Comparisons of measured and simulated significant wave height H_s of the sensor closest to the ice edge (sensor 3, measured: solid gray, simulated: solid black) and the sensor farthest from the ice edge (sensor 7, measured: dash gray, simulated: dash black) with different ice damping methods.

Figure: From Li et. al.

WAVEWATCH III - Global Wave prediction code

From the latest release

A dissipative source function, based on work by H. Shen and others, treats the ice as a locally continuous visco-elastic layer (i.e. a two-layer model).

Currently only the viscous layer model is in the wave prediction code.

Getting the scattering theory into the wave prediction code is the only way for this approach to be validated or even considered.

Conclusions

- The problem of understanding wave attenuation in the MIZ has been presented.
- The current state of the art in both meausrements and modelling has been presented.
- The process by which competing models are used and validated was discussed.