Ocean Waves Workshop

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Session 2 Presentation - Energetic Surface Waves Measured in Arctic Ice

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Energetic Surface Waves Measured in Arctic Ice

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1. Introduction

The interaction between ocean surface gravity waves and sea ice in the Arctic Ocean is receiving renewed attention due to the rapidly changing Artic environment [1]. The role of waves in this environment is thought to become more important as reduced sea ice extent provides a greater Arctic fetch [2, 3]. Wave action may accelerate the retreat of ice by fracturing floes, which effectively enhances melting rates by increasing their surface area [1]. This feedback loop seems to be an important mechanism for understanding sea ice extent in Earth's future (i.e. warmer) climate [2]. As such, in situ measurements of waves in the Arctic are crucial for understanding these processes.

In addition, accurate prediction of sea state in ice covered areas of the oceans (and lakes) is important for safety during military and commercial sea going operations. To inform the representation of wave dynamics in ice covered regions [4], all possible sources of wave data are being explored [3]. Here we present an energetic wave event encountered by R/V Lance during a cruise just north of Hopen Island, off Svalbard, Norway on 2 May 2010.

2. Methods

The GPS records were corrected for time stamp errors and spikes and divided into hourly blocks for spectral analysis. The 3rd generation spectral wave model SWAN was applied following the path of R/V Lance. This particular wave model does not have a representation for ice, so model runs were interpreted as an "ice free" scenario. Since the dimensions of R/V Lance act as a low pass filter, only low frequency waves (less than 0.12 Hz) were considered for comparison. Bow-oriented, digital photographs were taken hourly during the cruise, providing a qualitative record of local sea ice conditions. For a larger scale picture of the sea ice extent, archived runs of the sea ice model PIPS were used.

3. Summary of Results

Three distinct phases of ice-wave interaction can be identified in Fig 1: 1) wave blocking by ice (red), 2) strong attenuation of wave energy and fracturing of ice by wave forcing (yellow), and 3) uninhibited propagation of the peak waves and an extension of allowed waves to higher frequencies (above the peak) (green), presumably due to interaction with ice floes which were made smaller by fracturing. The wave model severely over-predicts energy wave energy during phases 1 and 2 but accurately predicts the low frequency energy in phase 3. The propagation speed of the fractured-ice front is estimated to be of some fraction of the peak wave group velocity. The results--where the wave energy impacts the ice in a way that in turn affects the wave energy--imply that two-way, wave-ice coupling is necessary and the predictive skill of a wave model in an icy environment will depend critically upon the resolution and accuracy of the ice model. These are the largest waves recorded in the Arctic Ocean with substantial ice cover present and we expect large waves to occur more frequently as the sea ice extent lessens in the future.

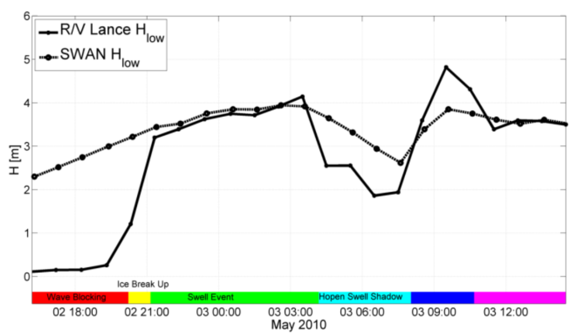

Figure 1. Low frequency wave height calculated from R/V Lance ship-borne GPS records and modeled with SWAN. Wave-ice interaction phases are color coded.

4. References

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[4] Rogers, W. E. and M. D. Orzech (2013), Implementation and testing of ice and mud source functions in WAVEWATCH III®, NRL / MR / 7320-13-9462, 31 pp