Proving and improving wave models in the Arctic Ocean and its MIZ

Prof Peter Wadhams
Cambridge Polar Consultants Ltd., 39-40 Grafton Street, Cambridge CB1 1DS, UK
Phone +44 1223 576433, Email peter.wadhams@gmail.com

Dr. Martin J Doble
Ice Ocean SASU, 86 boulevard Bischoffsheim, 06300 Nice, France
phone: +33 (0)493 763732 email: martin@ice-ocean.com

Award Number: N00014-13-1-0290
http://www.apl.washington.edu/project/project.php?id=arctic_sea_state

LONG-TERM GOALS

The long term goal of the project is to gain a significant improvement in our ability to understand, and model, the processes by which ocean waves, generated in the increasing expanses of open water which surround the shrinking Arctic ice cover, interact with the surviving ice cover and modify its properties.

OBJECTIVES

Objectives of the projects are to:

- Validate and improve the ECMWF WAM model in the Arctic, which predicts wave spectra at the ice edge on the basis of wind duration and fetch aross the open water;
- Extend the capabilities of the wavebuoys developed under the related MIZ DRI;
- Broaden the range of physical processes which contribute to modelled wave attenuation in the MIZ

APPROACH

We make use of wave buoys developed under the MIZ DRI to carry out further specific experiments on wave reflection from ice floes and wave-induced ice breakup; we bring in the specific skills of colleagues who are skilled in wave-ice modelling (Dr Michael Meylan, U. Newcastle Australia; and Dr. Jean-Raymond Bidlot, ECMWF) to interact with the experimental program in order to improve the theory symbiotically.

WORK COMPLETED/RESULTS

Task 1.1: Validation of WAM and comparison with in-situ data.

Dr. Jean-Raymond Bidlot has continued his work to validate the wave attenuation model, using the wave attenuation implemented in *Doble & Bidlot* (2013) to reproduce the in-ice wave conditions reported in *Kohout et al.*, 2014. Wave conditions along the buoy drift trajectories were modelled and are shown in Figure 1.

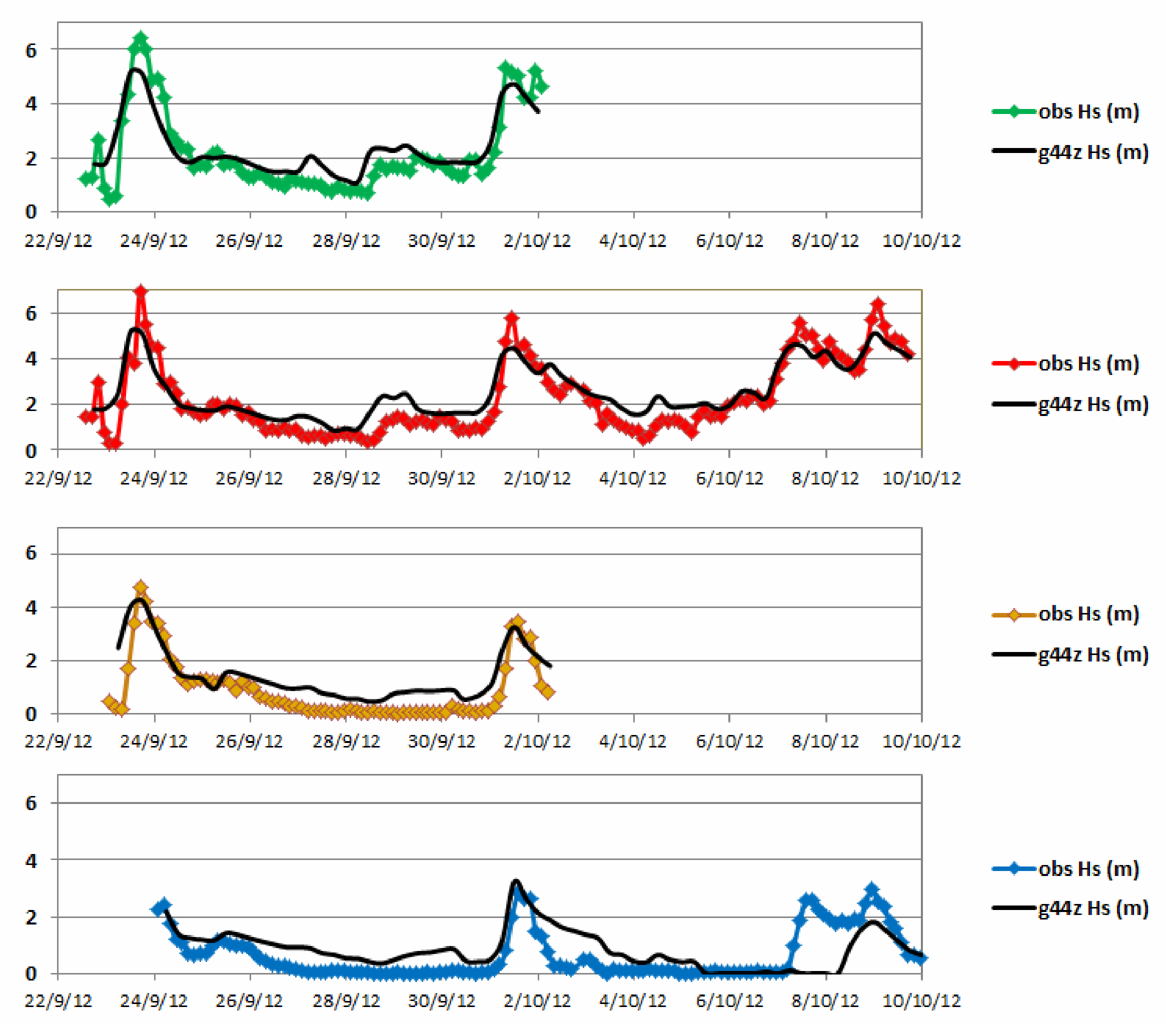

Figure 1: Significant wave height along the wave sensor drift trajectories as observed and from the model hindcast (black solid line).

While the comparison is already encouraging, we plan to seek alternative formulations (e.g. following Erick Rodgers WW3 work). These improvements will be tested in the Arctic as data become available from this and the closely-linked MIZ DRI.

Task 1.2: Taking WAM into the ice: Applying an enhanced WAM to delineate and track the extent and position of the wave-influenced zone.

Work has continued on the impact of including wave-in-ice attenuation in the fully coupled (atmosphere-wave-ocean-sea ice) model at ECMWF. Preliminary results were presented at the 22nd IAHR International Symposium on Sea Ice, Singpore, August 11 to 15, 2014 (Bidlot *et al*., 2014).

Task 2: Development and validation of improved attenuation models and parameterisations for the MIZ.

Dr. Martin Doble (IceOcean) and Dr. Michael Meylan (U.Newcastle) have made significant progress during this FY on the dependence of the attenuation coefficient on wave period and ice thickness, using data from the advancing Weddell Sea ice edge coupled with a process model (Doble, 2009). A linear relation between wave attenuation coefficient and ice thickness was demonstrated, and the gradient of this linear fit was also found to decrease linearly with wave period in the experiment space (7-14 seconds period). It was noted that these attenuation coefficients (in the pancake, or viscous, regime) are an order of magnitude larger than seen during the pack ice (and presumed scattering) regime. Amplitude dependence was not observed, in contrast to the data analysed by Meylan *et al.* (2014). Doble and Meylan are in the process of submitted a manuscript to the Journal of Geophysical Research with these findings.

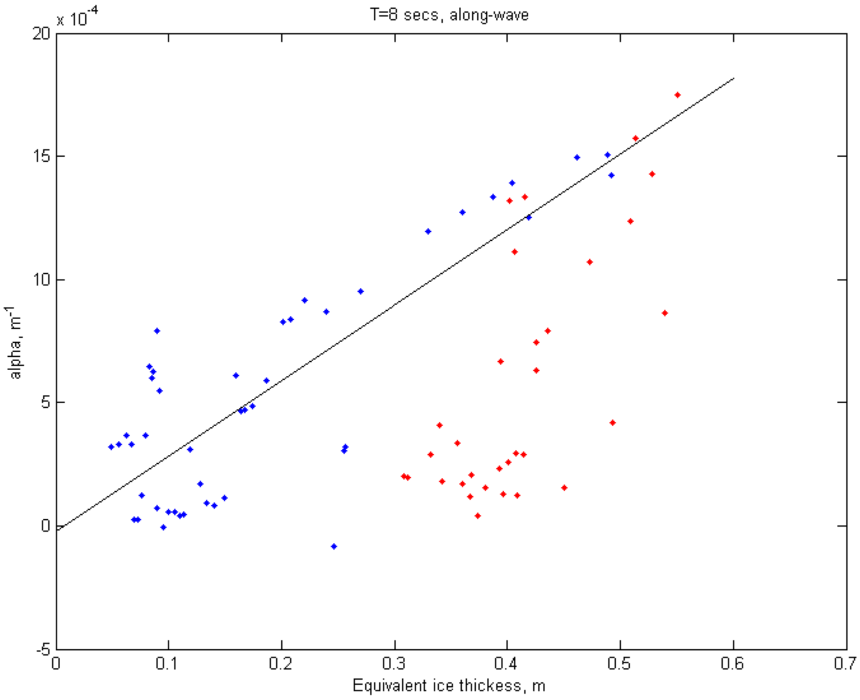

Figure 2: Dependence of wave attenuation on ice thickness, during the compression of the measuring buoy array (blue points). A linear dependence is clearly demonstrated.

Task 3: An ice edge reflection experiment

Work has continued in co-ordinating plans for fieldwork during the Oct/Nov 2015 *R/V Sikuliak* cruise, incorporating measurements from the planned 'Process Buoy' array. The electronics for these instruments has been built, and we plan to construct the hulls/batteries etc. during FY2015, to be shipped to join the vessel. In this process buoy study, buoys will be positioned and repositioned so as to remain specific small distances from the outer edge of a compact icefield and thus able to measure the directional spectrum of wave energy reflected from the front of the array. As an adjunct to this experiment, a further specific experiment will be carried out deeper into the pack, where the first large ice floe is found. This floe will be instrumented with eight wire strainmeters, based on the highly successful design used by SPRI throughout the 1980s and beyond to measure to very high resolution the flexure of ice floes. The purpose of the experiment is to measure the diustribution of flexural strain over the surface of a large floe so as to test models of flexural failure, the important parameters being (a) the wave energy, in period and amplitude, needed to cause break-up, (b) the sizes of the fragments generated by the breakup. This is vital information for use in models of the evolution of the floe size distribution in the MIZ, which require a valid model of the breakup process.

As a preliminary version of the floe breakup experiment, an experiment was carried out by P. Wadhams and his student T J Wagner in July 2012 on a giant ice island in Baffin Bay, in which the response to a breakup event was measured and the size of the broken-out iceberg fragment tested against models. It appears at the moment that this particular event correspponds to a response to a stress field created by the buoyancy of submerged rams around the edge of the berg, a mechanism which is somewhat distinct from that expected in large ice floes (Wagner et al., 2014).

IMPACT/APPLICATIONS

The application will be to the validation of wave scattering and flexural breakup models of the ocean-ice interaction process. This is of enormous importance if waves are to form a key component process of the summer ice development in the Beaufort Sea, furnishing, in high-resolution models such as that of Maslowsky, a component which helps determine the summer rate of ice retreat.
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RELATED PROJECTS

"Wave-ice interactions and the Marginal Ice Zone", MIZ DRI, Award Number N0014-12-1-0130

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Bidlot J.-R., Keeley S., and Mogensen K., 2014: Towards The Inclusion of Sea Ice Attenuation in an Operational Wave Model. *22nd IAHR International Symposium on Ice*, Singapore, August 11 to 15, 2014.
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PUBLICATIONS

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