

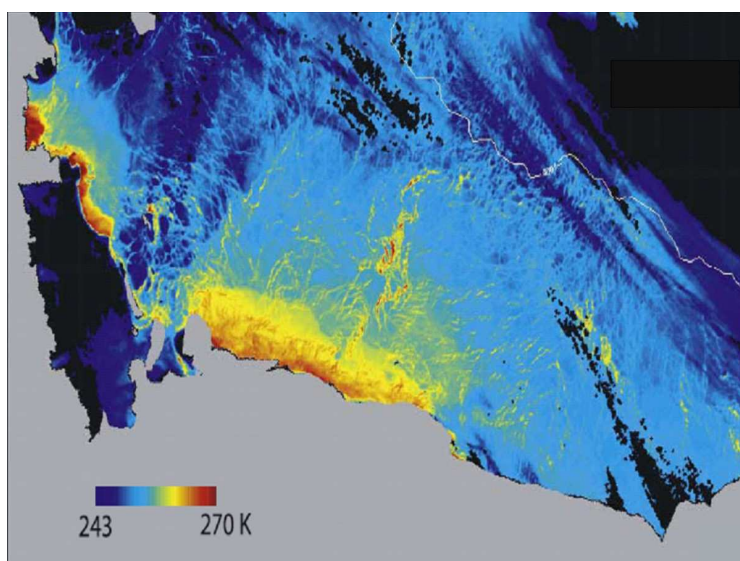
A Report on the Inaugural New Zealand Sea Ice Symposium

18 – 19 February 2010

Held at Abbey College, University of Otago, Dunedin

By The Participants

<http://www.maths.otago.ac.nz/seaice/home>



The Ross Sea Polynya observed with MODIS (Kwok et al. JGR 2007).

Introduction

Sea ice is the most dynamically varying part of the climate system, for example, it roughly doubles the effective size of Antarctica each winter. Unlike the Arctic where thick multi-year ice is prevalent (although less so recently), Antarctic sea ice is mainly first-year ice that has grown over the previous winter. For New Zealand sea ice is of direct interest, as in winter the sea ice edge is only the length of New Zealand to south of us.

Historically sea ice research in New Zealand has been built around the twin themes of ocean waves / sea ice interaction and sea ice structure. Within the symposium it is clear these remain strengths of the New Zealand sea ice community but new themes are emerging relating to oceanography, climate and remote sensing. Partly this can be attributed to a change in funding, with sea ice research linked to a larger climate programme, however, it also reflects the interests of the growing number of scientists working in sea ice. It is this increase in interest that provided the spark for this workshop.

Sea ice and waves

The influence of Vernon Squire in shaping sea ice physical science was very clear with 8 talks being by him (the first keynote) or his students/postdocs or the next generation. His opening keynote talk gave a fascinating overview of the field he has played a large role in developing for three decades both in New Zealand and internationally. There has been a significant resurgence of interest in the topic over the last two decades, especially in regard to

mathematical models, which, with the inclusion of heterogeneity, now do a good job of representing real sea ice in its natural state. Experimental work lags, unfortunately.

Models that relate to the scattering of ocean waves by sea ice are (somewhat artificially) split into two types: quasi continuous veneers in which waves interact with imperfections such as cracks, leads and polynyas, pressure ridge sails and keels, changes of material property or topography; or zones composed of a vast number of discrete, interacting ice floes. Squire outlined recent developments in this area that have seen mathematical models being developed for wave evolution over meaningful scales, i.e. over distances that correspond to the actual physical phenomena. Modern mathematical tools have successfully generated two-dimensional models for attenuation caused by scattering in both of the above situations, and these provide a strong backbone to this area of research. However, moving to a more realistic three-dimensional model is computationally demanding, and those that have been developed impose certain unphysical attributes to counteract this. Although the predictions for wave evolution given by these models are valid in the mid-range of wave periods, it is recognised that for both short and long periods, the current description of linear-wave scattering by thin-elastic plates alone is insufficient.

Expanding on Squire's talk, Gareth Vaughan gave an account of a 2-d mathematical model of wave evolution in the Arctic Basin using submarine-derived pictures of under ice thickness. This model also introduces a viscosity term that intended to extend its applicability into the long-wave regime. Furthermore, Luke Bennetts described the latest 3-d modelling methods and presented some preliminary results for techniques that will eliminate some of the unphysical features that facilitate computations. Phil Weir discussed a framework for a numerical model he is devising for his PhD, which are intended to accommodate waves that cause non-linear strains in the ice.

A challenge with mathematical approaches is to find appropriate validation data. Mike Meylan gave a provocative and amusing talk on the role of complexity and validation if we are to push such understanding forward. Although it generated some humour, Mike's point was important and probably was the closest the meeting came to being a workshop where there was actual discussion and debate in the open forum. Alison Kohout presented an outline of an ambitious experiment to generate new results on wave attenuation in the marginal ice zone that might be considered an answer to the challenges laid out in the Squire and Meylan talks. Fabien Montiel also described upcoming laboratory experiments in Nantes, France that would generate validation data for some of the above models.

Oceanography

Sea ice is clearly influenced by and is an influence on ocean processes. Miles McPhee presented the second keynote lecture linking sea ice and ocean processes from work in both polar regions noting differences and similarities and also emphasizing the dramatic changes taking place in the Arctic. Also he demonstrated the subtleties of cold-water oceanography and how narrow the division between stability and mixing is, under the right circumstances. Miles was able to attend as he was coincidentally visiting NIWA under the auspices of the Royal Society ISAT Linkages fund.

One of the big differences between polar regions is the presence of ice shelves. These shelves affect the ocean properties making possible the curious phenomenon of platelet ice in McMurdo Sound. This may have far reaching consequences for ice shelf influence and structure – a factor only now being incorporated in to large scale modelling. Natalie Robinson linked the regional oceanography to platelet formation demonstrating the different bounds of ice ocean interaction under shelf influence can all be found in McMurdo Sound. Craig Stevens described very new data looking at mixing at the edge of a glacier tongue – a proxy for an ice shelf. This showed the variability in the background flows that were enhanced by local topography. Mike Williams presented work initiated by the Marsden Fund on frazil/platelet mechanics in the water column looking at how families of ice particles transform in the water column.

Large scale sea ice climate interactions

The representation of sea ice in large scale climate models is challenging, and largely controlled by the model resolution. However, Sam Dean showed that with improved model physics, models are able to start capturing more of the interannual variability in sea ice particularly in the Ross Sea Polynya, which previously had been poorly represented. Sam also presented Jim Renwick's talk on which focused on the large scale linkages between the

variations in atmospheric circulation and sea ice, especially the influence of El Nino-Southern Oscillation and the Southern Annular Mode on sea ice.

Ice Structure

The ocean talks highlighted the need to understand the year-round oceanography and ice growth. Pat Langhorne presented results synthesizing two winter experiments – an astounding achievement – that examine ice growth in the context of the ocean processes. The results show the dominant influence of the ice shelf on the water column, causing the temperature of the ocean to fall below its surface freezing point by mid-winter. The resulting heat flux to the ocean contributes to the thickness and structure of the sea ice cover.

Inga Smith described a method for determining sea ice growth rate retrospectively by measuring the portions of oxygen isotopes in the sea ice, Inga proposed a modification to the method to be used in the presence of platelet ice.

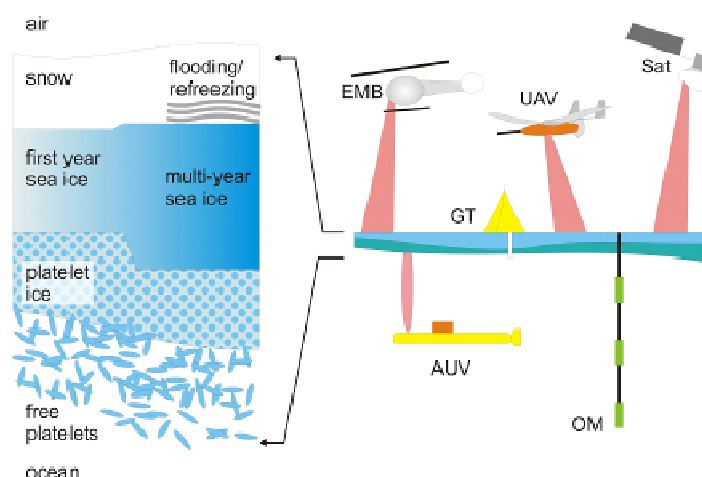
Remote Sensing

Given the difficulties and expense of working in polar regions, remote sensing is a hugely important topic. Wolfgang Rack described results of a pilot study to map the thickness of the sea ice and the slushy platelet layer at the ice-water interface in McMurdo Sound using helicopter-mounted electromagnetic induction techniques. These measurements require the thickness of the snow cover on the sea ice and these measurements, made using ground-penetrating radar, were described by Wendy Clavano. Extending the coverage of such measurements so that they can be linked to the data from satellite (specifically CryoSat) is seen as a critical extension to the work.

Materials

Robin Dykstra gave a fascinating account of the development of new technologies for looking at sea ice structure. He proposed a way for that might revolutionize determination of quantification of material anisotropic and porosity – especially important in the light of the structural information being determined earlier.

The electrical properties of sea ice allow a number of interrogation techniques to probe ice structure both for understanding its growth and internal microstructure as well as for understanding remote sensing data. Malcolm Ingham described both laboratory and field experiments testing techniques to measure the in-situ electrical permittivity of sea ice. Keleigh Jones described a significant suite of experiments from both polar regions demonstrating that the novel technique of cross borehole dc resistivity tomography can not only measure and monitor temporal changes in internal structure but in the Antarctic can also differentiate between columnar and incorporated platelet ice.



Proposed sea ice structure remote sensing experiment (Rack et al)

Other disciplines

The organisers deliberately set the scope on sea ice physics as it was felt that if it extended beyond two days the workshop nature would be diffused. It must be noted that there are groups working on geology (Andrill) and ecology (VUW, NIWA) that might be linked with.

The Student award and Demographics

Phil Weir was awarded the best student talk award for his presentation describing finite element modelling of an ice floe. Of the 24 presentations 3 might be considered by senior/late-career, nine by mid-career, five by early career and six by starting scientists. Is this a good split? If sea ice is a growing field should we be concerned that there is a mid-career bulge (or rather a dearth of new scientists)? Is there a mid-career bulge given most are part time on the topic?

Although unable to attend, the on-going contribution of Tim Haskell was recognised through many acknowledgements, co-authorships and Natalie Robinson's talk introducing Haskell Strait to the audience. His role in motivating, facilitating and overseeing polar science in New Zealand cannot be overstated. It is a challenge to many of us to work out a way to maintain and develop the mantle being passed by the senior scientists in a time of fractionated and somewhat ad hoc funding decisions.

International Linkages

Apart from the explicit attendance by Miles McPhee from the USA it was clear there are a number of international linkages with several people reporting on work with international links (Montiel – Nantes wave tank; Rack, Clavano & Haas; Kohout and Norway; Williams & Tasmania; Ingham & the Alaskans; Stevens & Canada) and several speakers having international affiliations.

The Future

It was not a goal of the workshop to develop any integrated science plan for the future of sea ice science in NZ. However, it was clear that many new linkages are possible and that much cross-fertilization is possible. It was also apparent that certain areas are less-well covered. There is clearly a dearth of observational work in the MIZ (it's difficult and expensive) yet this is where our mathematical strengths are. The in situ work, including the oceanography, is largely in the fast ice zone. Coverage could be extended by the use of satellite observations (CryoSat) but ground-truth measurements of snow cover, sea ice thickness and the properties ice-water interface are needed in order for these to reach their full potential.

Malcolm Ingham has offered to organise and host the next workshop in February 2012 at VUW. At the next meeting it would be useful to discuss future directions of research, and perhaps provide an outline of the planned work in the coming future. It would also be timely to consider the sea ice research in a post-K131 world as Tim Haskell's plans evolve.

Should we do anything different for the next workshop? We need a proper formal workshop photo. Have a round table discussion? Should we let biologists/geologists contribute? Perhaps a single keynote?

Funding and acknowledgements

Luke Bennetts, with help from Mike Williams, made the workshop happen. It was funded by the University of Otago Polar Environments Research Theme and NIWA. Miles McPhee was brought to New Zealand by the Royal Society ISAT Linkages fund.



Haskell Sea Ice Container Camp (Photo: Renwick)

Talks

Vernon Squire	Keynote: Contemporary perspectives on ocean wave / sea ice interaction
Miles McPhee	Keynote: Ice-ocean interaction at truly opposite poles
Gareth Vaughan	Waves in the Arctic Ocean
Fabien Montiel	Transient motion of an elastic plate in a two-dimensional wavetank
Michael Smith	Modelling of sea ice as a floating elastic plate
Sam Dean	The Ross Sea winter polynya in a high resolution global climate model, present and future
James Renwick	Atmospheric forcing of Antarctic sea ice on daily to weekly time scales (presented by Sam Dean)
Wendy Clavano	Snow thickness variations over first- and multi-year sea ice using ground penetrating radar
Wolfgang Rack	Ice thickness measurements in the McMurdo Sound area using the helicopter EM bird
Inga Smith	Sea ice thickness history from oxygen isotope analysis
Gareth Hegarty	Large amplitude wave-ice interaction
Luke Bennetts	A three-dimensional model of wave attenuation in the marginal ice zone
Alison Kohout	Consideration of an additional physical process in wave-ice interaction
Mike Meylan	Comparison of models for wave scattering by floating ice
Natalie Robinson	East vs west in McMurdo Sound, and a new signature of ice shelf water
Craig Stevens	Ocean turbulence next to an ice tongue
Pat Langhorne	Sea ice in supercooled water
Mike Williams	Modelling frazil ice within a supercooled water plume
Robin Dykstra	NMR measurements of brine fraction and diffusivity
Phil Weir	Applications of an FEM/FEM approach for the analysis of sea ice
Sean Buchanan	An impedance analysis of sea ice microstructure (presented by Malcolm Ingham)
Keleigh Jones	Cross borehole electrical resistivity tomography of Arctic and Antarctic sea ice
Malcolm Ingham	In-situ measurement of sea ice permittivity



Measuring sea ice thickness using hot wire gauges (photo: Stevens)