An Integrated Sea Ice Project For BREA: Detection, Motion and RADARSAT Mapping of Extreme Ice Features in the Southern Beaufort Sea

David G. Barber, Klaus Hochheim, Greg McCullough, David Babb, Anna Crawford, Alexander Komarov, Jennifer Lukovich, Matt Asplin

Community Based Monitoring
Charlie Haogak, Jim Wollki and J.D. Keogak

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Objectives

The project's overarching objective is to develop an understanding of physical and engineering characteristics of sea ice features as they relate to shipping and future oil/gas exploration activities in the Beaufort Sea.

The University of Manitoba work included

- collecting new data and integrating existing field data on
  - extreme sea ice features (ice thickness/ice mass balance)
  - sea ice motion (oceanic and atmospheric forcing)
- developing approaches to identifying significant ice features using remote sensing
- piloting a community based monitoring program in which Sachs Harbour residents monitored local ice thickness using an electro-magnetic induction system.

The U of M portion is integrated with components lead by Michelle Johnson (NRC, Ice thickness and strength) and Christian Haas (U of York, regional ice thickness distribution).
Presentation Outline

• Background
• Study Site
• Field Work:
  • multiyear ice motion by drifting ice beacons
  • in-situ winds and under-ice ocean currents by weather station and drifting current profiler
  • ice floe decay by ice mass balance measurements
  • ice thickness by surface electromagnetic induction surveys
  • ice drift and surface winds by satellite (synthetic aperture RADAR)
  • RADARSAT-2 detection/monitoring of extreme ice features (ice signatures)
  • Community Based Monitoring (Sachs Harbour) – ice thickness, CTDs
Ice Motion
The two sea ice gyres

Double Gyre Pattern

IABP ice motion
Multiyear ice extent decreasing since 1980s with thickest/oldest remaining along the Canadian Arctic Archipelago

http://polarbear.colorado.edu/IceAge/Age_Apr.html
The origins of Arctic Ice Islands

Adapted from Jeffries 1992
Multiyear ice drift

Ice beacon tracks from deployment in the eastern Beaufort Sea (August 2011) to the Chukchi Sea (C, D) and the Bering Sea (A, B, E) (Babb et al. 2013)
2012 Study Site West of Banks Island
- **Summer**: less coherent motion
  - Highly variable
  - Tidal/inertial loops
  - More responsive to local winds and currents

- **Spring**: strongly coherent drift
  - Less variable
  - Weaker inertial motions
  - Lagged response to winds and currents
In-situ winds and under-ice ocean currents


Minimum September sea ice extent in the Beaufort Sea (ice edge = 15% sea ice concentration)

Ice is more responsive to northerly winds into areas of open water (Lower internal stress). Southerly winds compress ice against itself and increase internal stress, similar to onshore and offshore winds.
Current structure in the mixed (freshening) layer under the ice. McCullough et al. In prep.
Selected ice tracks and under-ice summed velocity vectors. McCullough et al. In prep.
Multiyear ice decay

July 31 last observations
185 cm thick
Isothermal (> -1°C)

Initial ice thickness 523 cm

\[ F_{ow} = F_i (1- \alpha) A_{ow} \]

- \( F_{ow} \) Daily solar heat input
- \( F_i \) = Solar energy
- \( A_{ow} \) = area of open water

Babb et al. Submitted.
Ice thickness
Surface EM Induction Surveys (MYI)

April 11 Site S5 a) typical multi-year floe as seen from the helicopter, b) hand towed SEMI instrument, c) obtaining ground confirmation data for SEMI.
SEMI survey on S12, April 12, 2012 (file SIS00014). a) transects with survey segments delineated, b) large multi-year hummock, **7.94m avg.**; c) Pass-1, **5.93m**, d) Pass 2, **6.03m**.

SEMI survey on S14, April 12, 2012 (file SIS00012). a) pass 1 with segments delineated, b) segment 1, **5.5m avg.**; c) segment 2, **4.8m avg**; d) segment 3, **5.9m avg**.
Integrating existing data.... 2009 - 11

Example: 16 Aug, 2011

- 30% of floe is >4.0m
  - i.e. similar to floes S1 and S2
Ice drift and surface winds by satellite


Rotating floes west of Ellesmere Island, with ice drift vectors from sequential RADARsat-2 image (HV polarization). Komarov and Barber 2014.
Winds are valid over open water AND Ice motion

Wind speed [m/s]

Banks Island

Alexander Komarov
RADARSAT-2 detection/monitoring of extreme ice features
Detection of Extreme Ice Features: RADARSAT-2

Multi-year ice clearly distinguishable from first year ice in winter
Ice Island vs. first year ice (winter)
July 16, ice island clearly visible; multi-year ice barely distinguishable from roughened water surface

Ice Island albedo (spring and summer)
Hazardous ice features

Extreme Ice Features: Multi-year ice and ice islands (glacial)

Barber et al. 2013
Management of ice hazards

Barber et al. 2013
Conclusions

• At present rate, calving of Ellesmere I. ice shelves will continue to produce ice islands for at least two decades
• Multiyear ice will continue to be produced at the edge of the Canadian Arctic Archipelago

Challenges

• improved remote sensing detection methods are needed to distinguish hazardous ice features entrained in 1st year ice
• better local surface wind forecasting is needed to forecast short term average drift of the pack
• high resolution near-surface wind and current data would be required for useful forecasting of near-field motion of individual hazardous ice features
Community Based Monitoring
Community Based Monitoring: Sachs Harbour

Charlie Haogak, Jim Wollki and J.D. Keogak (Alternate)
Local ice thickness surveys

EM Induction surveys
Fred Lake

Ice Thickness/
Shoal detection
Possible link with DFO project looking at productivity (Christine Michel), extension into summer late fall.
Publications in prep/press


