Who are we?

Developing Marine Technological Solutions for Ocean Science

Brad deYoung
Physics and Physical Oceanography

Ralf Bachmayer
Engineering and Applied Science
Memorial University

MEMORIAL UNIVERSITY

INTERESTS

Developing autonomous capability for persistent ocean and ice sampling

Applying ocean gliders in ice-infested regions

Developing and applying new sensors for ice and iceberg studies

Integrating new ocean observations with ocean models

MOST PRESSING GAPS

Coordinated sampling amongst various users groups to really expand our observational understanding

Development of robust technologies for persistent and reliable work in harsh ice environments

Integration ice observations with other environmental observations and numerical models

WHAT I AM OFFERING

Platforms for ice observation – gliders, autonomous surface craft, aerial drone

Sensors and new algortihms for ice observation – radar, multibeam, laser range finder, Lidar, optical

Ocean observation and modelling together with ice observations

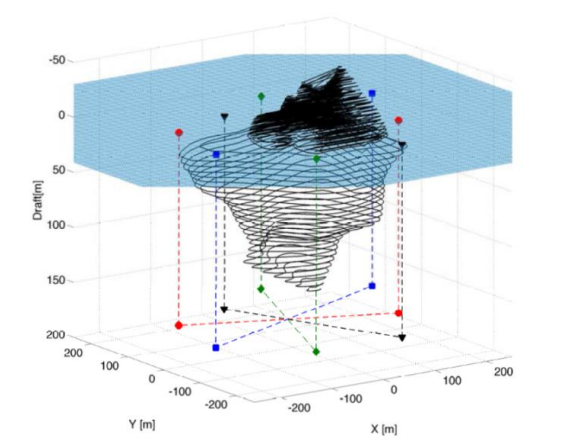
WHAT I AM LACKING/ CHALLENGES

Collaborative observations to enable complete data sets

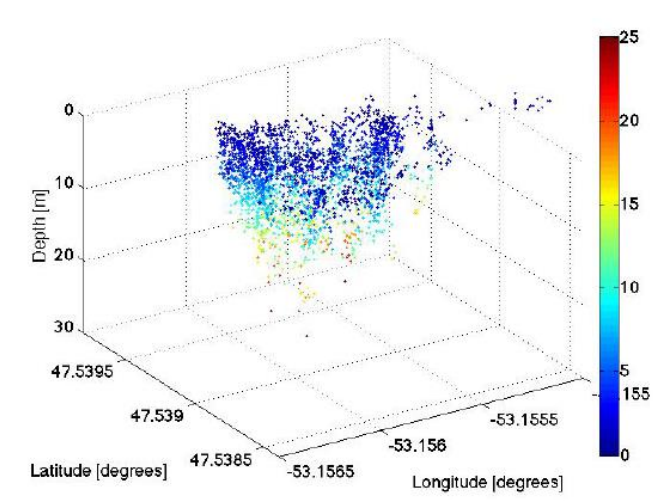
Opportunities to work in different environments, e.g. glacial fjord systems

Connections with private sector for further development of hardware and software technologies

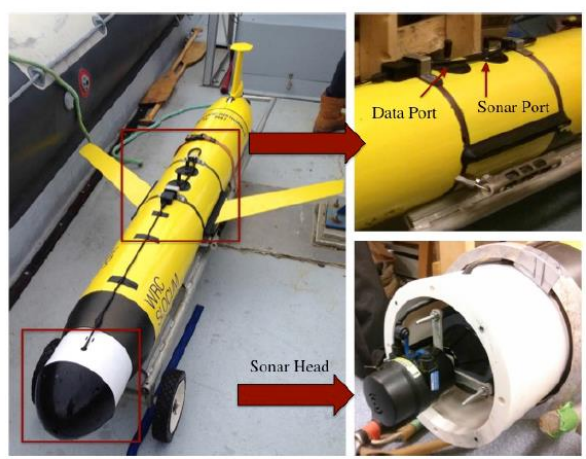
UNDERWATER MAPPING OF ICEBERGS USING SONAR



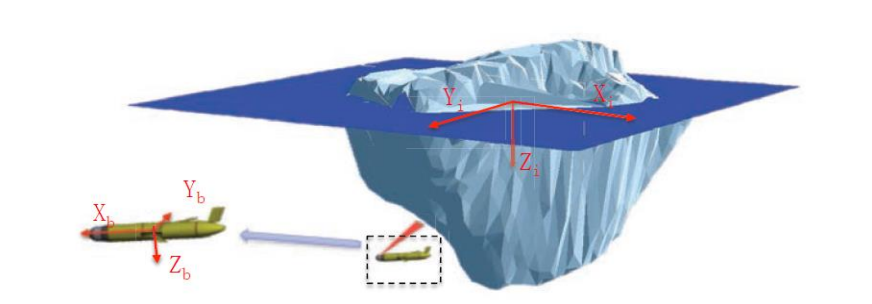
Simulation



Raw data

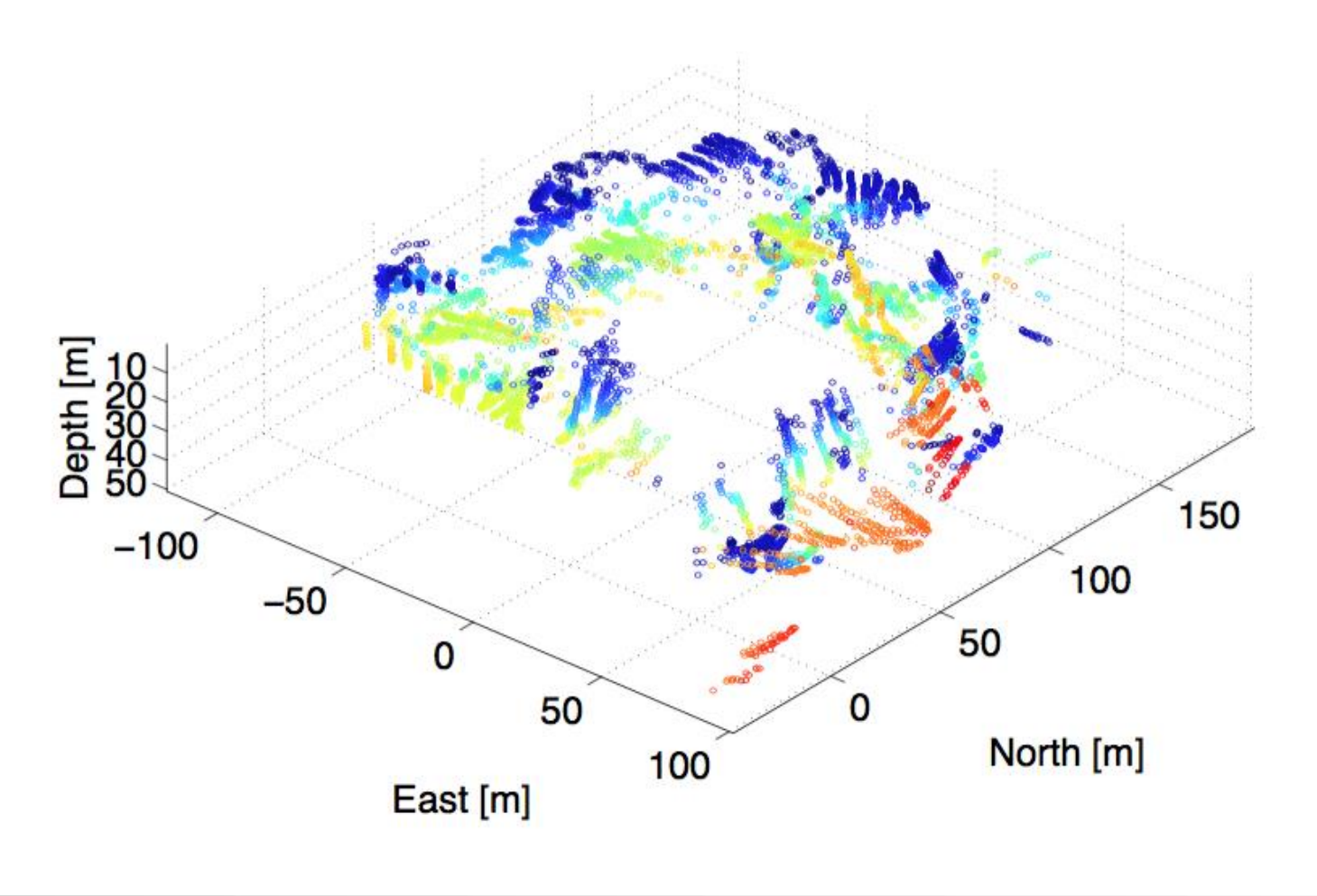


Glider AUV setup



Processed rendering

IMAGE OR ILLUSTRATION



REFERENCES

Zhou, M., Ralf Bachmayer, R., de Young B. (2014). Initial Performance Analysis on Underside Iceberg Profiling with an Autonomous Underwater Vehicle. Proceedings of MTS/IEEE Oceans2014, St. John's, Canada.

Zhou, M., Bachmayer, R., de Young, B. (2014). Working Towards Seafloor and Underwater Iceberg Mapping with a Slocum Glider. IEEE-OES AUV 2014, Oxford, United States.

Smith, N., Bachmayer, R. (2014). Development of Semi-Submersible Unmanned Surface Craft. Proceedings of MTS/IEEE Oceans2014, St. John's, Canada..

Claus, B., Bachmayer, R. (2014). Towards Navigation of Underwater Gliders in Seasonal Sea Ice. Proceedings of MTS/IEEE Oceans2014, St. John's, Canada.

Singleton, J., Bachmayer, R., de Young, B. (2013). Development of an Autonomous Underwater Moored Profiler. IEEE - Newfoundland Electrical and Computer Engineering Conference, St. John's, Canada.

Zhou, M., Bachmayer R., B. deYoung (2013). An Analysis of Iceberg Profiling Strategies using Unmanned Ocean Systems. IEEE - Newfoundland Electrical and Computer Engineering Conference, St. John's, Canada.

BERNIE BEAUPERTUIS/JASON MELVIN

Suncor Logistics -

Ice Management , Offshore Supply Vessel Operations, Arctic/Offshore Labrador Ice Operations

End User

INTERESTS

Here CONCISELY list your relevant interests. Be as specific as possible. Try to avoid listing generic topics.

- Physical Modelling (including deterioration)
- Ice Islands
- Ice Management
- Drift Modeling
- Remote Sensing
- Airborne and other Sightings
- Environmental Inputs
- Long Range Forecasting

MOST PRESSING GAPS

Within an identified context, what 2 or 3 max gaps are you aware of that are worthy of attention? Why do you think they are a high priority?

Drift Modelling

Long-term forecasting

Ability to identify actual targets (aerial surveillance , vessel radar, Government support of industry.

WHAT I AM OFFERING

Describe what skills, equipment, knowledge, data or resources you could be willing to share if a mutually beneficial collaboration were defined with anyone.

Experience.

Historical ice management data.

Limited access to marine resources when practical.

WHAT I AM LACKING/ CHALLENGES

Describe what skills, equipment, knowledge, data or resources you need to address the gaps you perceive as most pressing. Describe any challenges.

Improved accuracy of

-drift Modelling

-long-term forecasting

-accurately identifying actual targets (aerial surveillance , vessel radar, Government support of industry.


HYDRAMARINE

WHO I AM

Pat Barron Jr.

Iceberg Program Coordinator

Oceans Ltd.

St. John's Newfoundland & Labrador

President

Iceberg Logistics Inc.

INTERESTS

My relevant interests are to renew all aspects of iceberg research.

For example : Monitoring and detection, charting, management, Metocean.

MOST PRESSING GAPS

Data Collection…Data Collection…Data Collection

Metocean, Measurements

Monitoring & Detection

Management Equipment Improvements (Standardization??)

WHAT I AM OFFERING

Anything that is not proprietary.

WHAT I AM LACKING/ CHALLENGES

Use Whatever Equipment / Personnel is Required to get the Job Done – for example - Data Collection – MetOcean, Iceberg Measurements – Physical, Aerial Density, Flux

Comprehensive Training

Kara Gate, Russia, August 2014

REFERENCES

"YOU CAN'T IMPROVE WHAT YOU DON'T MEASURE"

Zoomer Magazine

June 2015

WHO I AM

Mike Hicks

US Coast Guard International Ice Patrol (IIP)

Background:

- US Coast Guard Commander ("retired" in 2007):
  - Ship driver and anti-submarine warfare officer
  - Oceanography Instructor at the US Coast Guard Academy
  - Supervisor at Search and Rescue Coordination Center Alameda, CA
  - Former IIP Commander and Deputy Commander
- Team member for ESA's Polar Thematic Exploitation Platform (P-TEP) http://p-tep.polarview.org/

Combination end user, data source and researcher

INTERESTS

- Leading IIP's transition from aerial to satellite SAR and/or Unmanned Aerial System (UAS) reconnaissance
- Improving IIP's drift and deterioration modeling capability
- Increasing aerial iceberg reconnaissance efficiency through airborne radar testing

MOST PRESSING GAPS

- In-house automated iceberg detection from SAR imagery
- SAR acquisition, processing and analysis training and expertise at IIP
- Continuous iceberg size & position data (5-7 days drift)
- Funding to replace iceBerg Analysis and Prediction System (BAPS)

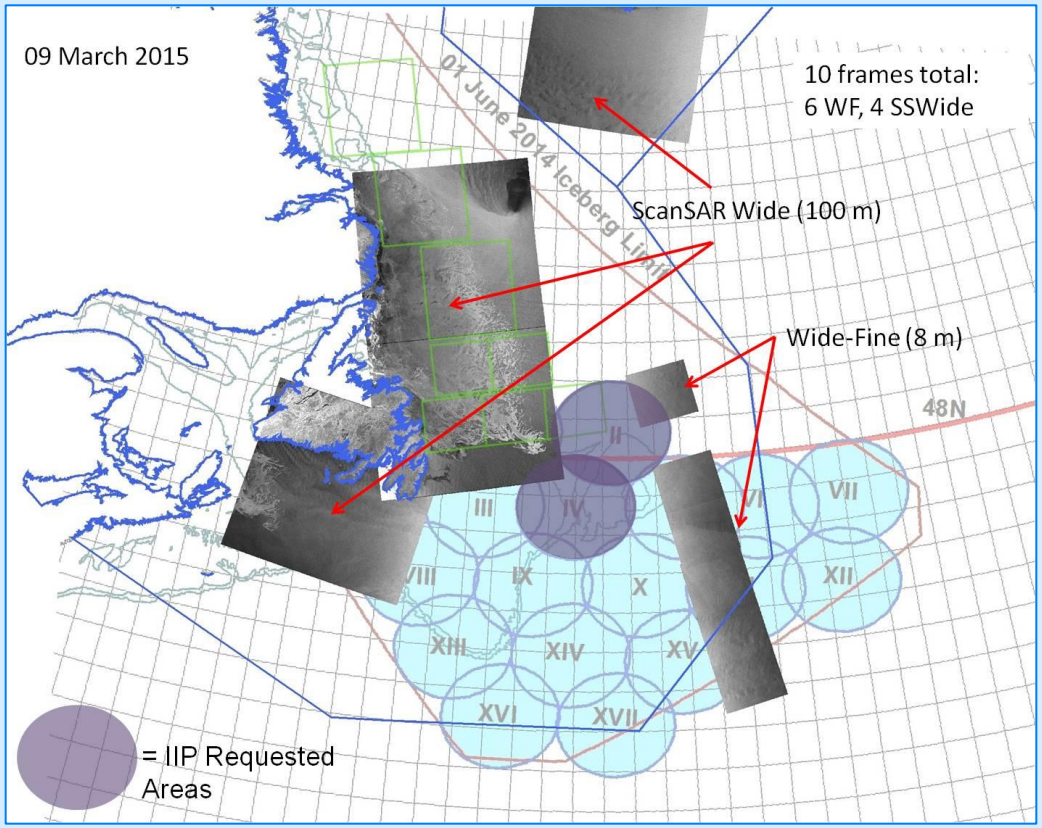
WHAT I AM OFFERING

- OPS permitting, the use of USCG HC-130J aerial reconnaissance for validation
- Aerial iceberg observation skills and knowledge
- Drifting buoy data from Grand Banks/Labrador Current region
- Associating IIP mission and history with collaborative efforts to build public/government support

WHAT I AM LACKING/ CHALLENGES

- Access to an automated algorithm for IIP to analyze imagery within ~12 hours of image collection.
- Continuous data (5-7 days of drift) is necessary for drift and deterioration model improvements.
- Additional data synchronized with satellite acquisition is also essential for coincident analysis and for testing algorithm(s).
- Personnel with the correct skill set for SAR image analysis

IIP SATELLITE RECONNAISSANCE CONOPS



- IIP CONOPS defines Areas of Interest
  - North of 48ºN
    - RSA-2 ScanSAR Narrow (or comparable)
  - South of 48ºN
    - RSA-2 Wide-Fine (or comparable)
- IIP CONOPS assumes Wide-fine (or comparable mode)
- Example from March 2015
  - IIP requested areas
  - RADARSAT-2 Acquisitions

REFERENCES

- Science Applications International Corporation (2011). *Scenario Development: A Study to Determine the Feasibility of using Space-Borne Iceberg Reconnaissance in International Ice Patrol Operations.* May 2011.
- IIP. (2013). Report of the International Ice Patrol in the North Atlantic (2013 Season), Bulletin No. 99, Appendix B. *2011 and 2012 Satellite Coincident Analysis.*
- USCG R&D Center (2015). Technical Report: *Alternative Asset Iceberg Reconnaissance Demonstration.* March 2015. (on request)
- IIP (2015). Position Paper: *Satellite Reconnaissance History, Transition and Plan.* April 2015.
- IIP. (2013). Report of the International Ice Patrol in the North Atlantic (2013 Season), Bulletin No. 100, Appendix B. *2014 Transatlantic Shipping Behavior.*

Alon Stern

Postdoctoral researcher at

Geophysical Fluid Dynamics Laboratory (GFDL)

Princeton University

Advisors: Alistair Adcroft, Olga Sergienko, Bob Hallberg,

Current research focus: Iceberg modeling

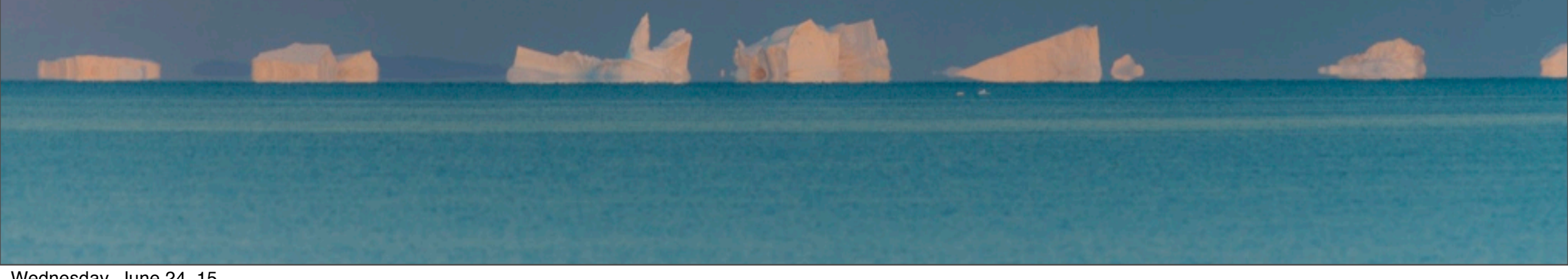
Other Research Interest: Polar oceanography, ocean-ice interactions

PhD Advisor: David Holland (Courant Institute, NYU)

PhD Dissertation Title: Ocean heat delivery mechanisms beneath Antarctic ice shelves

Interests:

1) Iceberg modeling
2) Iceberg decay mechanisms
3) Iceberg melt parametrizations
4) Iceberg fracture parametrizations
5) Iceberg interactions with sea ice, topography, and other bergs
6) Coupling ocean and land ice models using iceberg
7) Mesh-free (Lagrangian) sea ice modeling (using the same code!)
8) Total fresh water and latent heat flux in the ocean due to icebergs



Most Pressing Gaps

1) Observational confirmation of melt rates parametrizations

a) $M_b = 0.58|\vec{v} - \vec{v_o}|^{0.8} \frac{\tilde{T_o} - \tilde{T}}{L^{0.2}}$ (basal melt)

b) $M_e = \frac{1}{12} S_s (1 + cos(\pi A_i^3))(T_o \tilde{} + 2)$ (melt due to wave erosion)

c) $M_v = (7.62 \times 10^{-3})\tilde{T_o} + (1.29 \times 10^{-3})\tilde{T_o}^2$ (melt due buoyant convection)

2) Data on iceberg breakup (no parametrizations exist)

3) Calving and iceberg size and mass distributions (data)

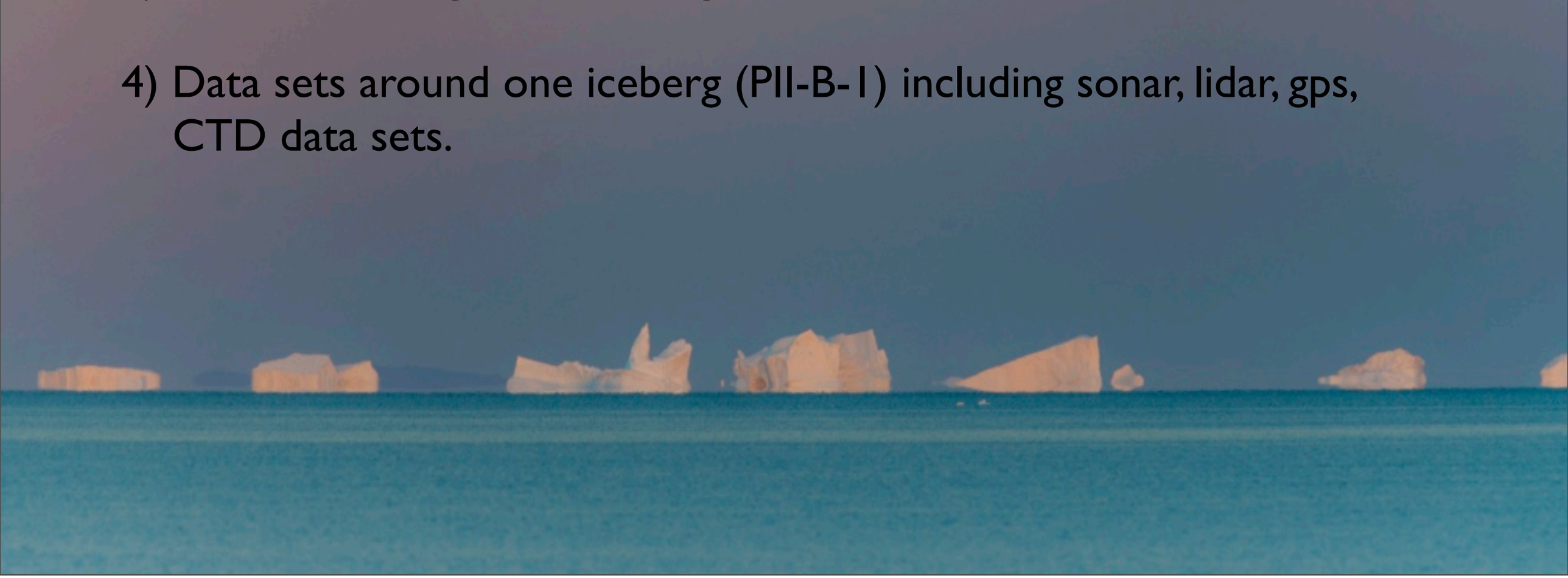
What am I offering?

1) I can test iceberg parametrizations in the GFDL coupled model

2) I have a working iceberg model written in Matlab, which allows for iceberg interactions (suitable in a fjord, for example)

3) I have a winning smile and a good sense of humor

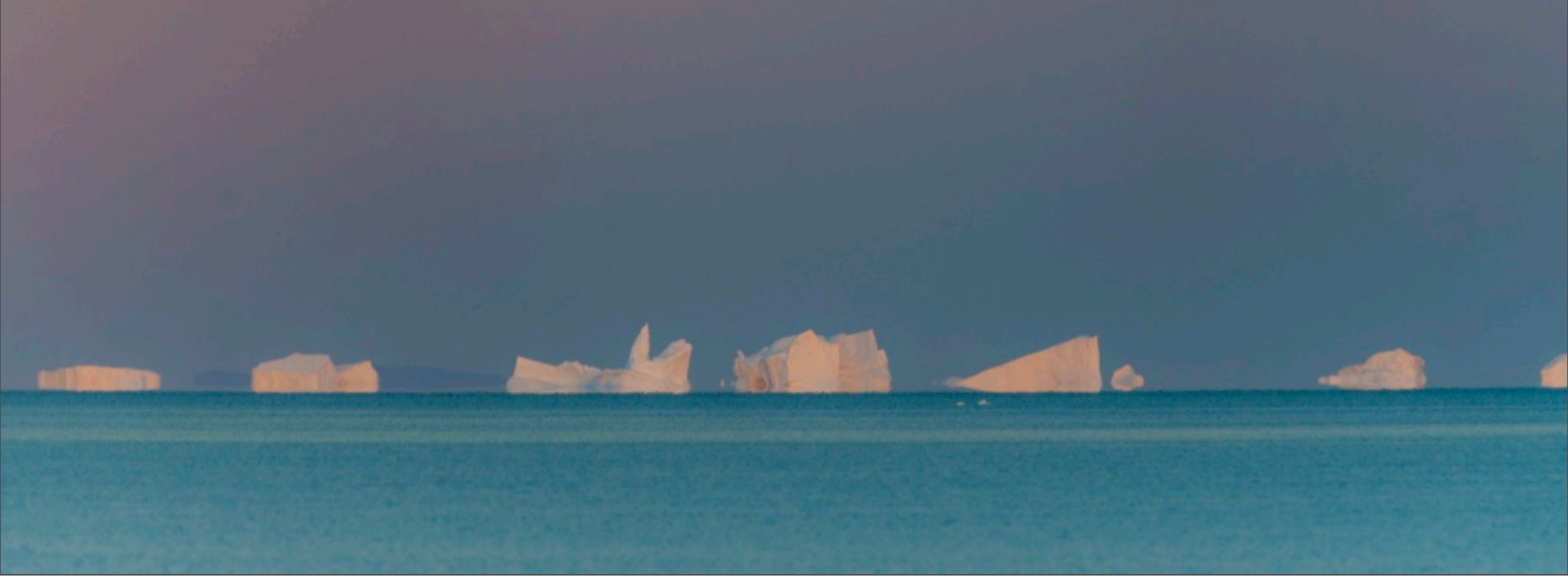
4) Data sets around one iceberg (PII-B-1) including sonar, lidar, gps, CTD data sets.



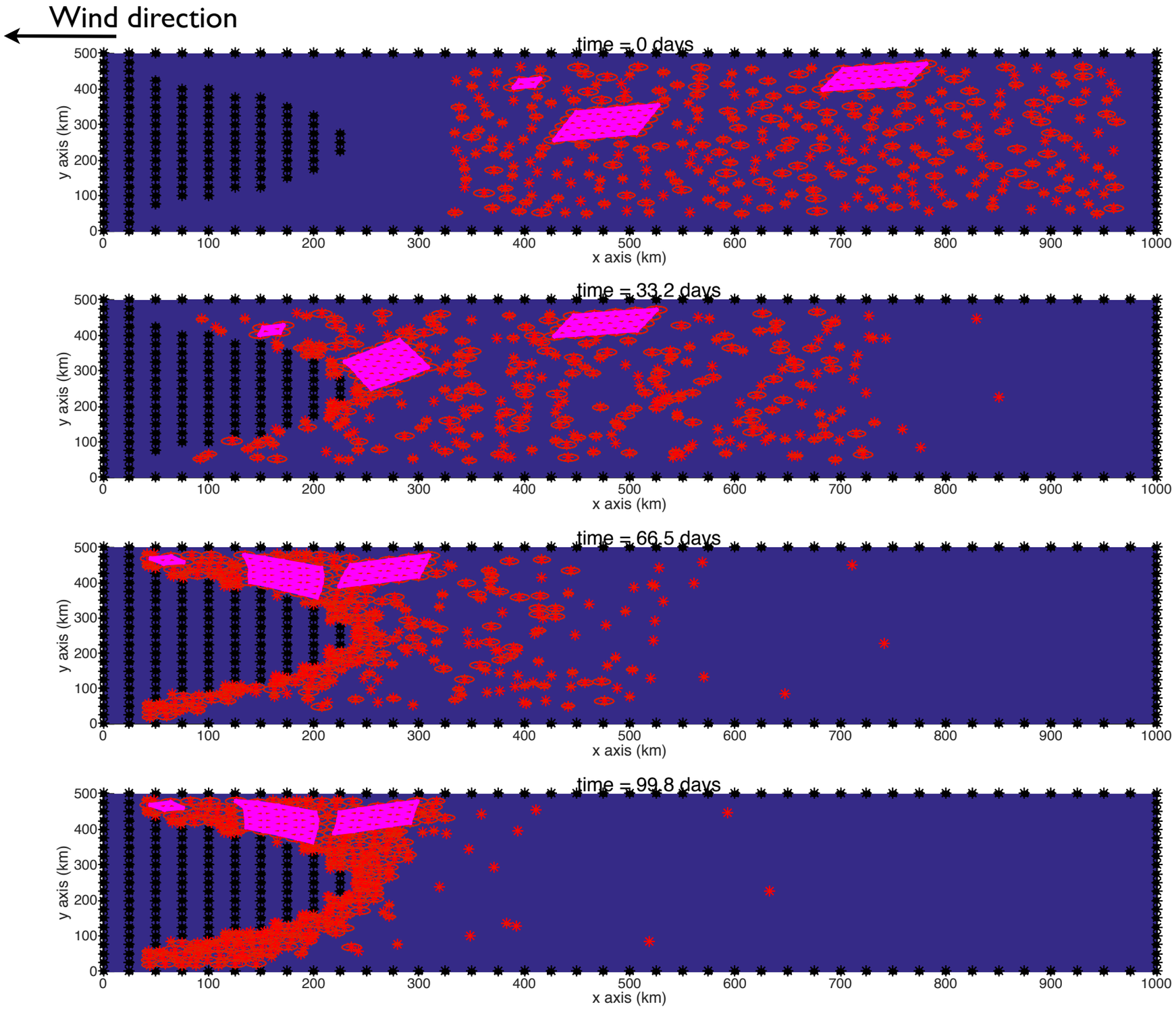
Challenges and needs

1) Need calving and iceberg size and mass distributions (data) from satellite data

2) Would love to be involved in field work!!!
(but my new boss does not go to the field...)



Interesting Figure (current research)



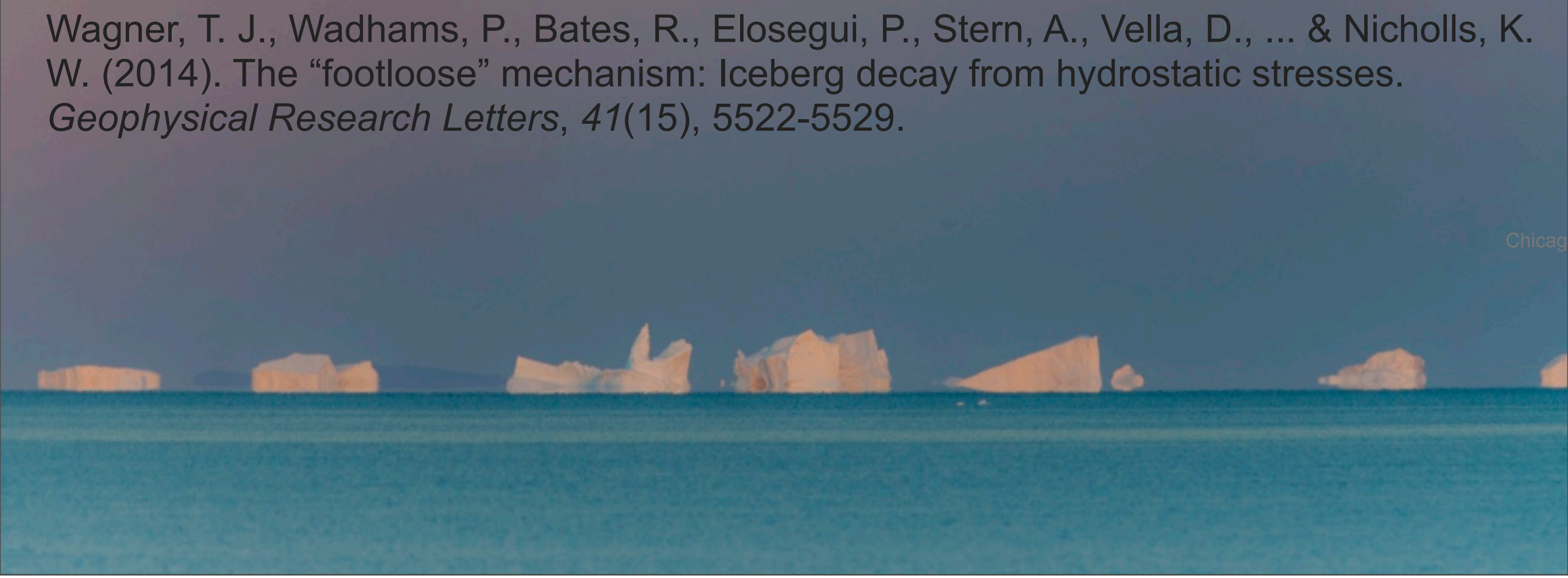
Iceberg interactions: Tabular and non-tabular icebergs being advected towards the coast

Reference

Martin, T., & Adcroft, A. (2010). Parameterizing the fresh-water flux from land ice to ocean with interactive icebergs in a coupled climate model. *Ocean Modelling*, *34*(3), 111-124.

Tournadre, J., Bouhier, N., Girard−Ardhuin, F., & Rémy, F. (2015). Large icebergs characteristics from altimeter waveforms analysis. *Journal of Geophysical Research: Oceans*, *120*(3), 1954-1974.

Wagner, T. J., Wadhams, P., Bates, R., Elosegui, P., Stern, A., Vella, D., ... & Nicholls, K. W. (2014). The “footloose” mechanism: Iceberg decay from hydrostatic stresses. *Geophysical Research Letters*, *41*(15), 5522-5529.



WHO I AM

Hello, I am Sean McDermott of Horizon Ice. I am an operational ice manager and run ice management, ice advisory and ice alerting programs in the Caspian Sea and NE Greenland.

Although my offices are in Halifax, Nova Scotia, I spend more time overseas in either Kazakhstan (winter) or Greenland (late summer and fall). I started in the ice business in the 80s, back when Dome Petroleum and Beaudril were in their heyday in the Beaufort Sea, a period of rapid technological advancement in a developing art known as ice management.

My core strengths are in operational ice management with a background in ice, meteorology, oceanography and software development. I am both a source of data and an end user.

INTERESTS

I am interested in developing ice management programs in areas where ice is a direct threat, where the challenge is to operate within the ice field not avoid it entirely. This means I have a keen interest in better weather forecasting, more frequent image acquisition at higher resolutions and models that may help predict ice behaviour, especially ice pressure, better than they currently do.

MOST PRESSING GAPS

Operations are moving more northward all the time with current seismic and subsequent oil exploration likely moving north of 80°N within the next 10-15 years. The ice in these areas is more challenging with the loss of a robust first-year ice barrier. We need clusters of satellites to provide tighter coverage, better management programs to handle the risks and new people to gain experience within this field.

WHAT I AM OFFERING

Unique and long-term experience in a variety of ice areas. I have a strong background in image interpretation, threat analysis, program development and software development. For data, I have a large dataset of Beaufort Sea (Alaskan and Canadian) ice drifts and winds as well as most of the original SAR/SLAR imagery acquired during the 1980s.

WHAT I AM LACKING/ CHALLENGES

I am part of a team working on a complete ice management solution (command & control system) for a client that will incorporate imagery, weather data both forecast and observed, ice forecasts, real-time currents, upward looking profilers (gates) and UAV (drone) integration that will drive alerting processes, asset management and a myriad of reports.

IMAGE OR ILLUSTRATION

I sent the video under separate cover, enjoy…

REFERENCES

Any reading list I would recommend would by nature of the subject , be vast. Any decent meteorology / oceanography texts at an entry level would be a good start and progress ever onward to books like ice mechanics. I would be very interested in reviewing any list anyone had the time to put together to provide relevance for the work I do if that would be helpful.

WHO I AM

- *Richard McKenna, R.F. McKenna Associates*
- *PhD, Civil Engineering*
- *35 years of experience in engineering analysis, experimentation, project management, and technical assistance*
- *Researcher and consultant*

INTERESTS

- *Physical environmental criteria for arctic design and operations*
- *Arctic data collection strategies*
- *Improved numerical and probabilistic modelling techniques*
- *Ensuring human safety and minimization of environmental impacts through the development of codes and standards*

MOST PRESSING GAPS

- *While iceberg shape has considerable influence on drift, detectability, response to hydrodynamic forcing, and interaction with ships and structures, it is difficult and expensive to measure accurately*
- *Specifically*
  - *link between deterioration processes and shape*
  - *characterization and modelling of global fracture processes*
  - *rapid measurement techniques in an operational setting, maximizing useful information content*
  - *hydrodynamic response, particularly when in proximity to ships and structures*

WHAT I AM OFFERING

- *Experience*
- *Context for human presence in the arctic*
- *Understanding of the physical environment*
- *Problem-solving skills*
- *Research strategies*

WHAT I AM LACKING/ CHALLENGES

- *Real progress takes time*
- *As significant challenge is the acquisition of unbiased research-quality data documenting iceberg attributes (location, size, shape, drift, deterioration, forces) over long periods of time*

IMAGE OR ILLUSTRATION

Ellesmere Island, 1984

REFERENCES

McKenna, R. (2015) Iceberg climate, morphology, and design situations, in Proceedings of the 23rd International Conference on Port and Ocean Engineering under Arctic Conditions, June 14-18, 2015, Trondheim, Norway

McKenna, R., Fuglem, M., and Crocker, G. (2014) Uncertainty in ice actions on offshore structures, in Proceedings of the Offshore Structural Reliability Conference (API-OSRC 2014), September 16-18, 2014, Houston, USA

McKenna, R., Fuglem, M., and Crocker, G. (2014) Uncertainty in 100 and 10,000 year ice loads on offshore structures, paper ICETECH14-167, in Proceedings of 11th International IceTech Conference on Performance of Ships and Structures in Ice, July 28-31, 2014, Banff, Canada

McKenna, R. and King, A.D. (2009) Modelling iceberg shape, mass and draft changes, in Proceedings of the 20th International Conference on Port and Ocean Engineering under Arctic Conditions, June 9-12, 2009, Luleå, Sweden.

McKenna, R. and Ralph, F. (2007) Determination of iceberg size and shape from multiple views, in Proceedings of the 19th International Conference on Port and Ocean Engineering under Arctic Conditions, June 26-30, 2007, Dalian, China.

McKenna, R.F. (2006) Iceberg shape representation and generation, in Proceedings of ICETECH 2006, Banff, Alberta, Canada.

McKenna, R.F. (2005) Iceberg shape characterization, in Proceedings of POAC'05 Conference, Potsdam, New York, USA.

McKenna, R., Ralph, F., Power, D., Jordaan, I., and Churchill, S. (2003) Modelling iceberg management strategy, in Proceedings of POAC'03, Vol.2.

Croasdale K., Brown R., Campbell P., Crocker G., Jordaan I., King T., McKenna R., and Myers R. (2001) Iceberg risk to seabed installations on the Grand Banks, in Proceedings of POAC'01, Vol.2.

WHO I AM

Adrienne Tivy, Canadian Ice Service

Adjunct, International Arctic Research Center

Past, National Research Council

Researcher/Data Provider

INTERESTS

1) *Develop iceberg climatology for Canadian Waters; collaborate with DMI on an iceberg climatology for all of Baffin Bay / East Coast Canada*
2) *Seasonal / Inter-annual forecasting of iceberg populations*
3) *Assimilation of in situ observations into ice drift models to improve forecasts*

MOST PRESSING GAPS

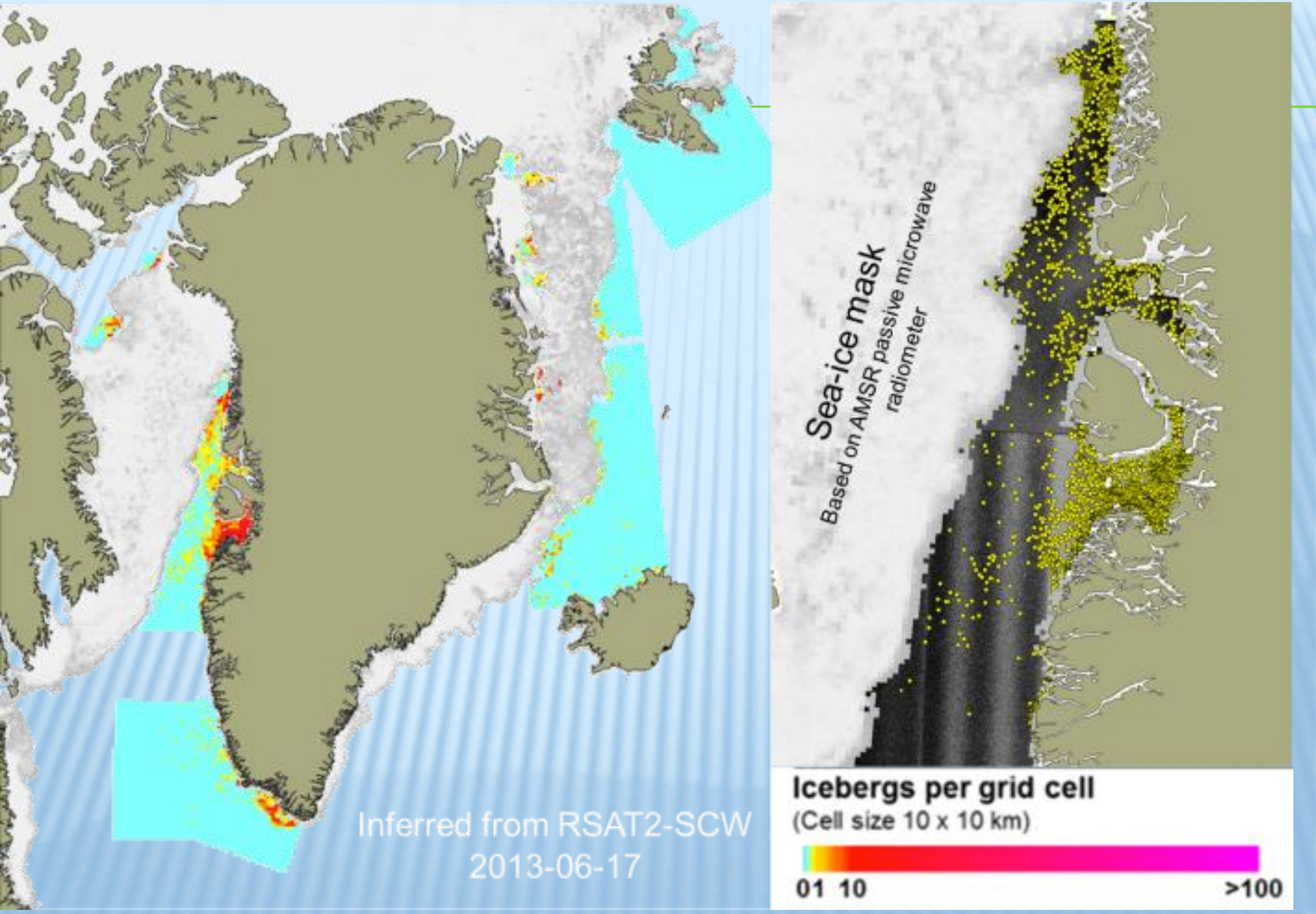
1) *Iceberg population estimates*
2) *Field observations to develop/test iceberg drift and deterioration models*
3) *Field observations to develop/test automated detection algorithms for satellite data*

WHAT I AM OFFERING

1) *CIS/gov't data*
2) *Climatology/statistics*

WHAT I AM LACKING/ CHALLENGES

1) *Iceberg population data*
2) *Causes of inter-annual variability in iceberg populations*


Sea-ice mask
Based on AMSR passive microwave radiometer
Icebergs per grid cell
(Cell size 10 x 10 km)
01 10
>100
Inferred from RSAT2-SCW
2013-06-17

WHO I AM

Angela Cheng

Canadian Ice Service

Physical scientist, GIS and remote sensing

INTERESTS

- ***Spatial analysis, spatial distribution of icebergs***
- ***Automated detection of icebergs in remote sensing***
- ***Iceberg climatology***

MOST PRESSING GAPS

- ***Iceberg and ship discrimination***
- ***False alarms in automated detection***
- ***Validation datasets for berg/ship discrimination***

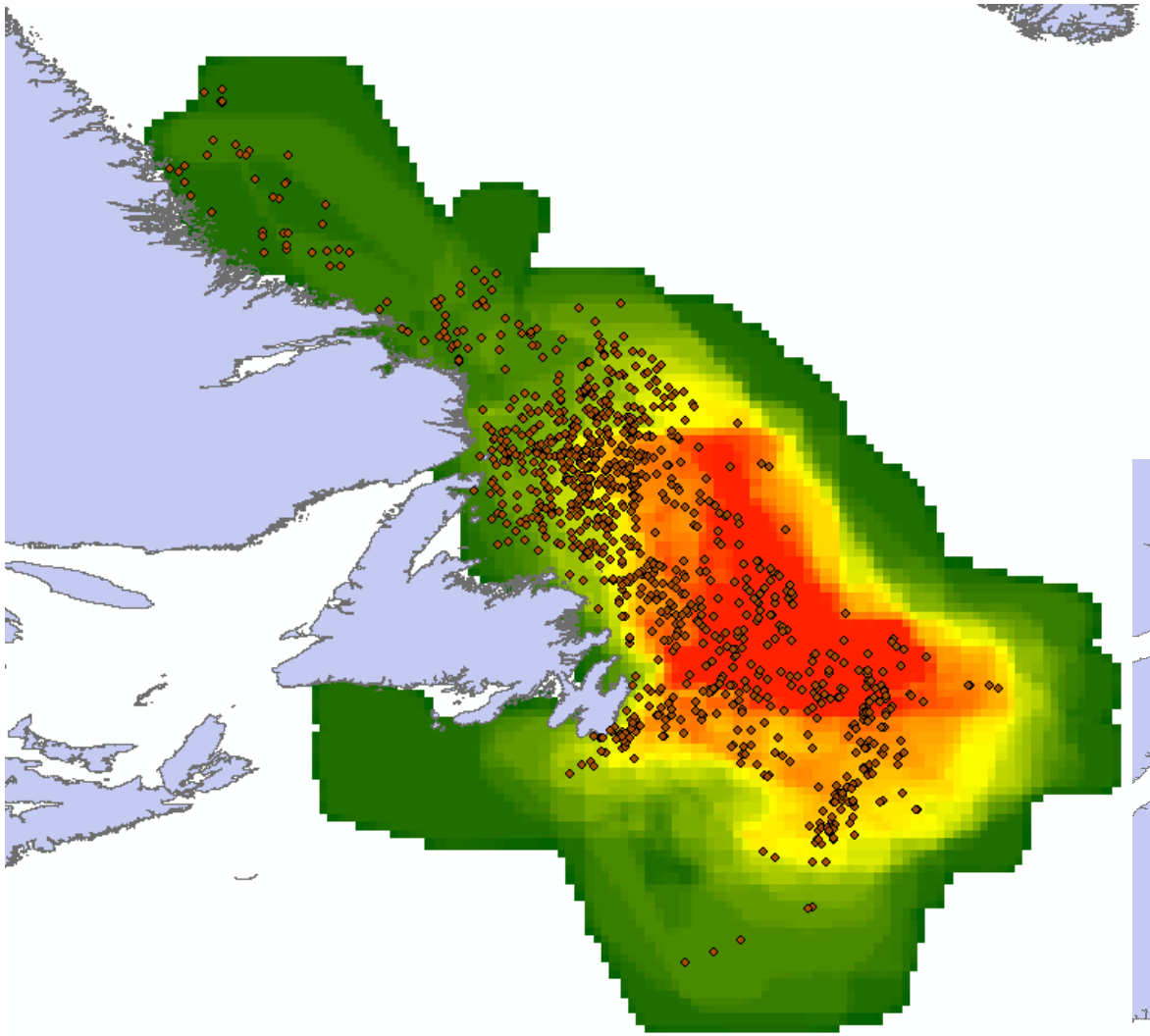
WHAT I AM OFFERING

- ***Spatial analysis***
- ***Spatial statistics***
- ***GIS***
- ***Remote sensing***
- ***Some validation datasets***

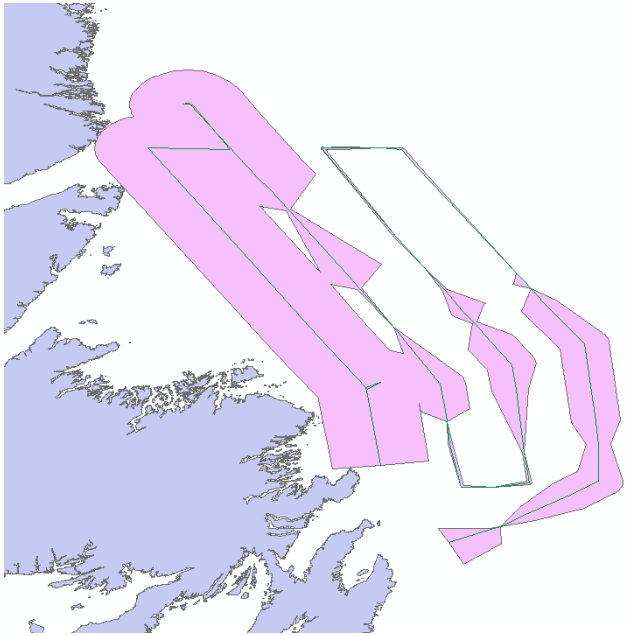
WHAT I AM LACKING/ CHALLENGES

- ***Validated icebergs in remote sensing imagery with attributes (for example, size, shape)***

Image or illustration



Spatial distribution of icebergs with respect to monitoring frequency



WHO I AM

Ian D. Turnbull

Ice Researcher at the Centre for Arctic Resource Development (CARD) in St. John's, NL, Canada

Background and core skills: Ph.D. in geophysics (University of Chicago, 2008); sea ice and iceberg dynamics analysis and modeling, sea ice thermodynamics modeling, deterministic and probabilistic model development, sea ice and iceberg drift forecast model development and implementation, on-ice field measurements (ice coring, temperature and salinity) and instrumentation deployments (ice and ocean current tracking buoys, weather stations).

INTERESTS

- *Operational iceberg drift forecast modeling and model development.*
- *Operational ocean current forecast modeling and model development for use in iceberg forecasting.*
- *Iceberg environmental characterization (historical and present analyses of local iceberg conditions in terms of shape, size, drift dynamics).*

MOST PRESSING GAPS

- *Operational iceberg drift modeling: improving model parameterizations of keel depth and shape as this has a major impact on the ocean current forcing outcome of the models.*
- *Improving short-term local forecasts of changes in non-tidal ocean currents as this is a major impediment to improving the iceberg trajectory forecasts.*

WHAT I AM OFFERING

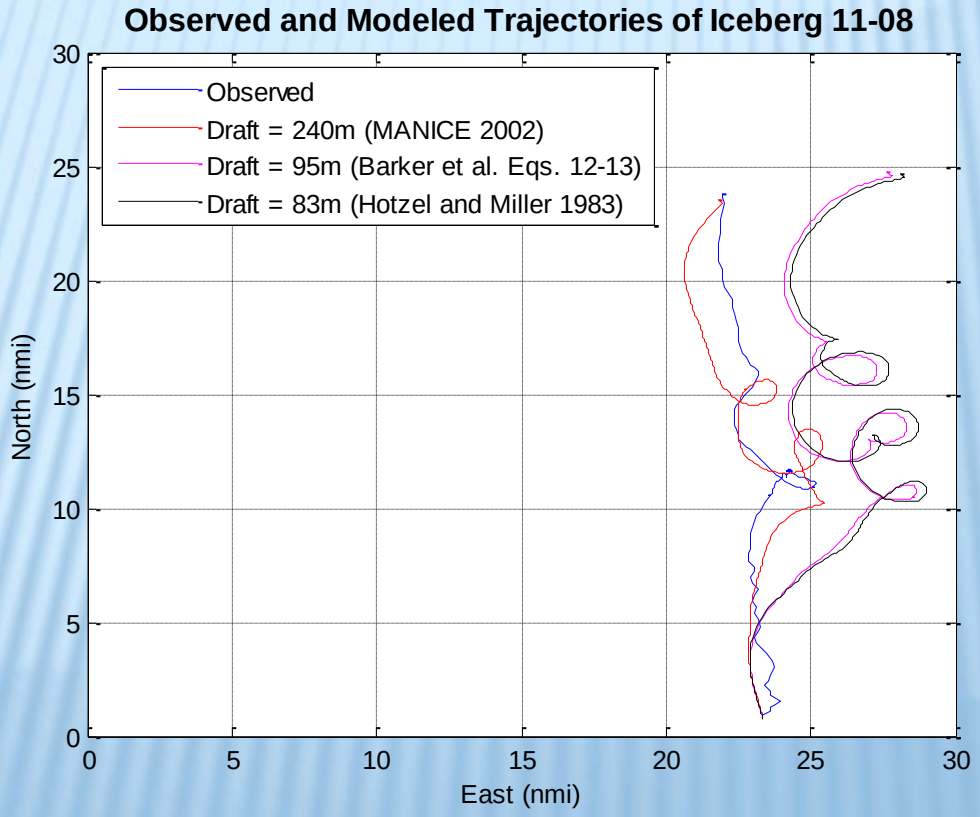
- *At CARD I have been involved in efforts to collect iceberg trajectory data offshore Newfoundland and Labrador, hence CARD has been building a database of iceberg dynamics.*
- *I have built operational iceberg drift forecast models that have been utilized in an offshore operation.*
- *I have experience in analyzing and characterizing local iceberg environments.*

WHAT I AM LACKING/CHALLENGES

- *We would like access to better iceberg shape data (particularly keel), both archived and data being acquired currently through sonar profiling technology.*
- *We would like to acquire in-situ wind and ocean current data driving iceberg drift (such as through ADCP deployments) rather than relying so heavily on modeled/reanalysis metocean data.*

IMAGE OR ILLUSTRATION

Importance of properly estimating iceberg keel depth in a drift forecast model shown in figure below from Turnbull et al., 2015 (CRST); the model is sensitive to iceberg keel depth input.



REFERENCES

Fournier, N., Nilsen, R., Turnbull, I., McGonigal, D., and Fosnaes, T. Iceberg Management Strategy for Baffin Bay 2012 Scientific Coring Campaign. POAC 2013 Conference, Espoo, Finland.

Turnbull, I.D., 2010: Drift of large tabular icebergs in response to atmospheric surface pressure gradients, an observational study. Antarctic Science, 22(2), pp. 199-208 doi:10.1017/S0954102010000027.

Turnbull, I.D., Fournier, N., Stolwijk, M., Fosnaes, T., and McGonigal, D. Operational Iceberg Drift Forecasting in Northwest Greenland. Cold Regions Science and Technology, 110 (2015), 1-18, 2015.

Turnbull, I.D., Fournier, N., and Stolwijk, M. Prediction of Localized Ocean Currents from an Acoustic Doppler Current Profiler for Use in Operational Iceberg Forecasting Offshore Northwest Greenland, POAC 2015 Conference, Trondheim, Norway, June 14-18, 2015.

Turnbull, I.D., Taylor, R.S., Sarracino, R., Slaney, A., and Roche, L.C., 2015: Analysis of Iceberg, Pack Ice, and Ocean Current Dynamics Offshore Newfoundland and Labrador from Satellite-Tracked Buoys During the 2014 Ice Season. AMSE 34th International Conference on Ocean, Offshore and Arctic Engineering (OMAE), St. John's, Newfoundland and Labrador, Canada, May 31 – June 5, 2015.

Turnbull, I.D., Taylor, R.S., Slaney, A., and Roche, L.C., 2015: Field Data for Sea Ice and Iceberg Drift Offshore Newfoundland and Labrador. Arctic Technology Conference (ATC), Copenhagen, Denmark, March 23-25, 2015.

WHO I AM

Philippe Lamontagne, Research Council Officer

National Research Council, Ice Mechanics group at Ocean Coastal and River Engineering in Ottawa.

Background: Software Engineering with specialities in System Integration, Geomatics and Image Processing

I am: Researcher, Service Provider, Data Source Provider and Data Collector

INTERESTS

Collecting iceberg sightings, iceberg shapes and management events to be included in various databases. (on behalf of Denise Sudom)

Iceberg drift behaviour (including in a pack ice situation)

Continuously improving existing operational iceberg drift forecasting system

Integrating the iceberg drift forecasting system with the best wind, wave and ocean current forecast available.

MOST PRESSING GAPS

Detecting glacial ice in pack ice

Modelling iceberg drift in pack ice

Visualizing uncertainty in modelled iceberg drift

WHAT I AM OFFERING

NRC licenses for:

Operational Iceberg Drift Forecasting System

supporting current operations over the Grand Banks

Operational Pressured Ice Forecasting System

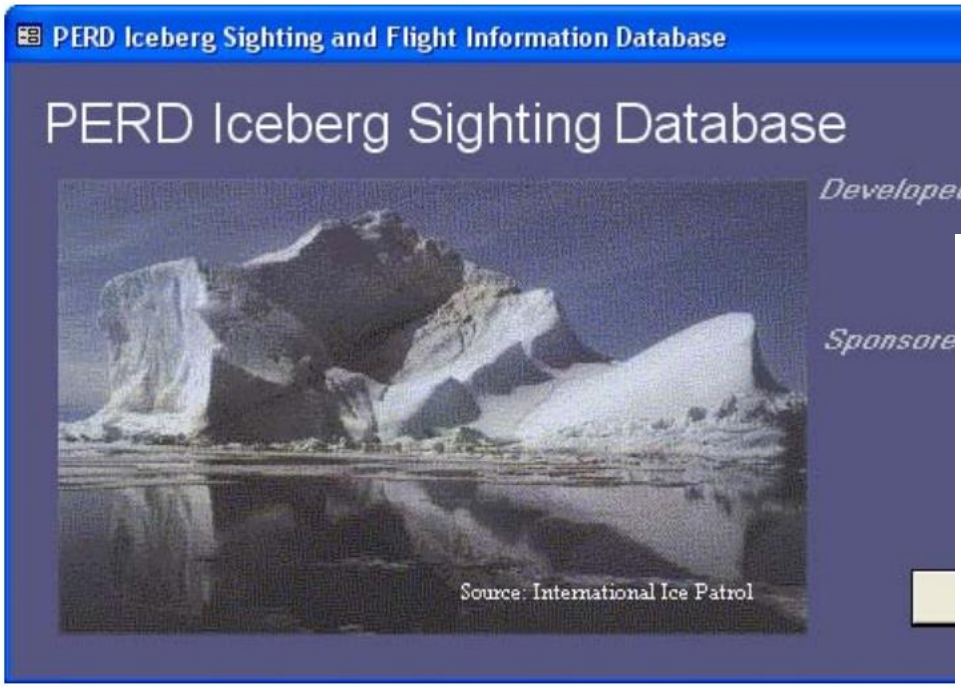
supporting research addressing iceberg drift modelling in pack ice

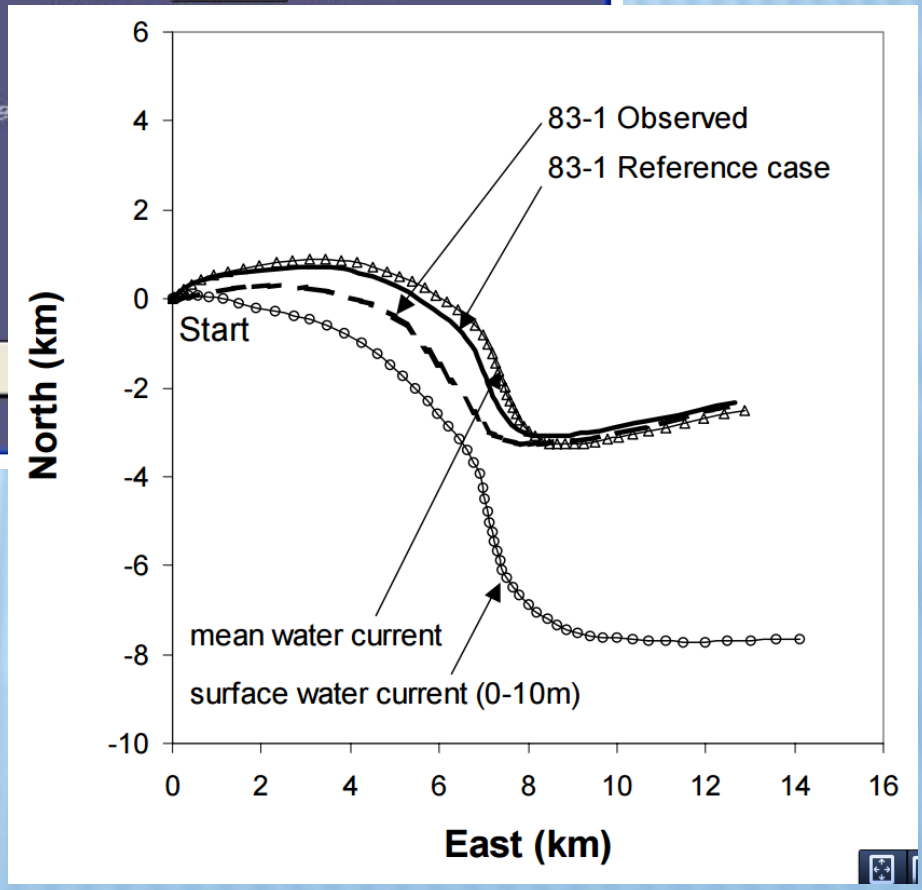
WHAT I AM LACKING/ CHALLENGES

Industry feedback on needs for:

- Glacial ice drift modelling capabilities
- Iceberg management in a pack ice situation

NRC DATABASES AND MODELLING WORK





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WHO I AM

Leif Erik Andersson

PhD student at NTNU (Norwegian University of Science and Technology)

I studied mechanical engineering and specialised in process/chemical engineering.

I am doing my PhD at the department of cybernetics (control engineering).

Core skills are data analysis, estimation and filtering techniques, optimal control techniques as well as optimization.

INTERESTS

During my PhD I will study the movements of icebergs.

If a icebergs approaches a platform many information about the iceberg itself (shape estimation, movement) and also more precise information about the weather (wind, wave, current) are available. My goal is to use those information to update a simple operational iceberg model frequently to reduce the uncertainty within the forecast of the iceberg movement (forecast time ~48h).

Furthermore I will try to identify situation where the operational iceberg model is trustworthy and situations where the iceberg model cannot be trusted.

MOST PRESSING GAPS

Most challenging is to get reliable information about the current at the iceberg location. The current is one of the major driving forces of the iceberg, but in the same time also the one with the highest uncertainty.

A interesting scientific project would be to develop a toolbox which is able to model a 3D-CFD model of an iceberg. Such a tool could be used to compare with the operational model and detect "faults" within the operational model.

WHAT I AM OFFERING

I can help with any kind of data post processing, filtering and estimation problem (if something more advanced than a low-pass filter is used). This includes also topics like model identification or design of experiment.

(Maybe within the context of this meeting not really required), but I can also help with any kind of control application, most interesting for me would be model predictive control or adaptive control applications.

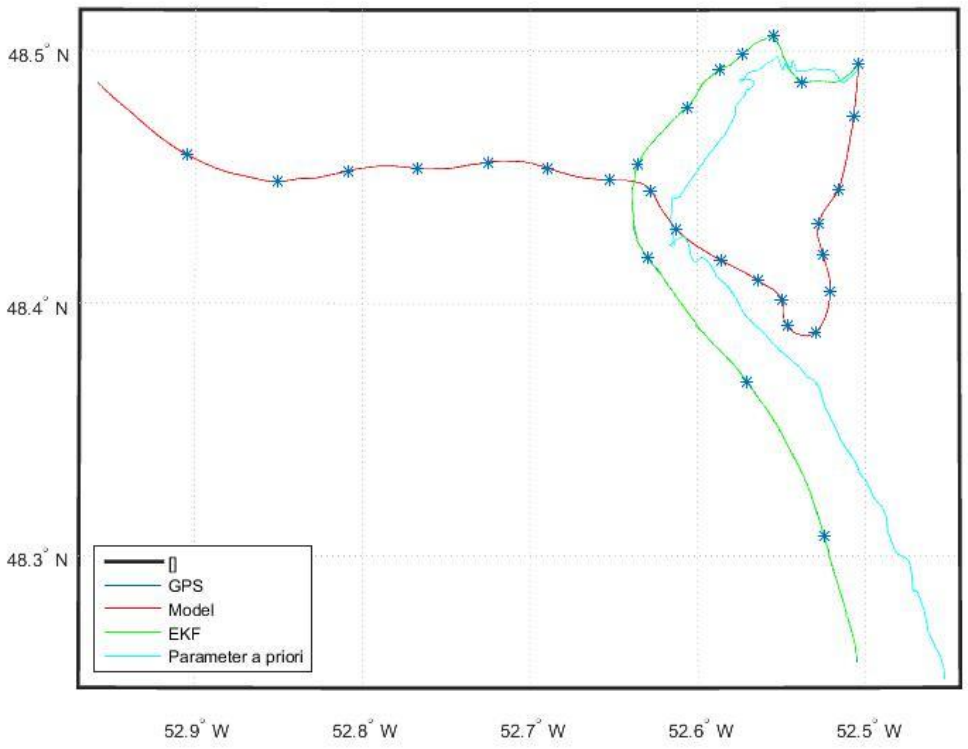
WHAT I AM LACKING/ CHALLENGES

Within the Offshore Newfoundland Research Expedition we surveyed 5 icebergs. However only one was in open-water, all others were surrounded by sea-ice. The open-water berg is a very good initial point for my studies and I will test the algorithms on this berg. However statistically is one berg not sufficient.

Therefore I am interested and more complete data sets (complete is if all environmental inputs (wind, wave, current) and the geometry of the iceberg was measured as well as the iceberg movements for a certain amount of time)

IMAGE OR ILLUSTRATION

trajectories



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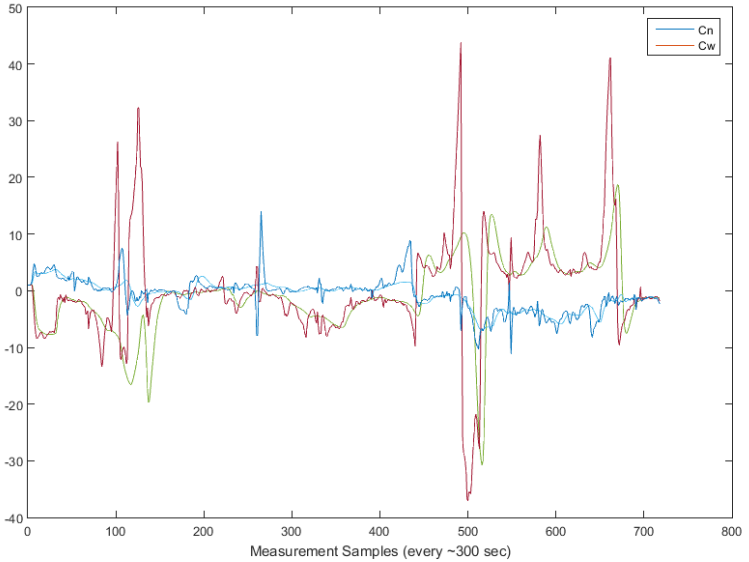

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  - Garrett, C. Statistical prediction of iceberg trajectories. *Cold Regions Science and Technology,* 11(3):255 – 266, 1985
  - Kubat, I., Sayed, M., Savage, S. B., and Carrieres, T. An operational model of iceberg drift. International Journal of Offshore and Polar Engineering, 15(2):125-131, 2005.
  - Keghouche, I., Bertino, L., and Lister, K. A. Parameterization of an iceberg drift model in the Barents sea. *Journal of Atmospheric and Oceanic Technology*, 26(10):2216-2227, 2009.
  - Eik, K. Iceberg drift modelling and validation of applied met-ocean hindcast data. *Cold Regions Science and Technology*, 57:67-90, 2009.
- Estimation related:
  - Rawlings, J. B. and Bakshi, B. R. Particle filtering and moving horizon estimation. *Computers & Chemical Engineering*, 30(10-12):1529-1541, 2006.
  - Simon, D. Optimal State Estimation: Kalman, H Infinity, and Nonlinear Approaches. *Wiley*, 2006.

WHO I AM

Tom Carrieres, Ice Modelling Manager, Canadian Ice Service

Applied Research aimed at improving operational services

INTERESTS

- *Evaluation of various sources of ocean currents as drivers for iceberg drift and deterioration model*
- *Improved approaches to ensemble modelling, ice island drift forecasting, sea ice effects*
- *Improved operational products including probabilistic, longer duration, etc*
- *Combining ensemble forecast model with SAR based detection building towards increased automation*

MOST PRESSING GAPS

Iceberg deterioration (crucial for CIS and IIP iceberg limits)

Ensemble modelling using coupled atmosphere-ice-ocean ensemble forecasts

Accurate ice island forecasts

WHAT I AM OFFERING

Long term interest in iceberg/hazard modelling and corresponding seed funding/level of effort

Existing iceberg forecasting model within an operational context

Linkages with operational services and environmental modelling/R&D

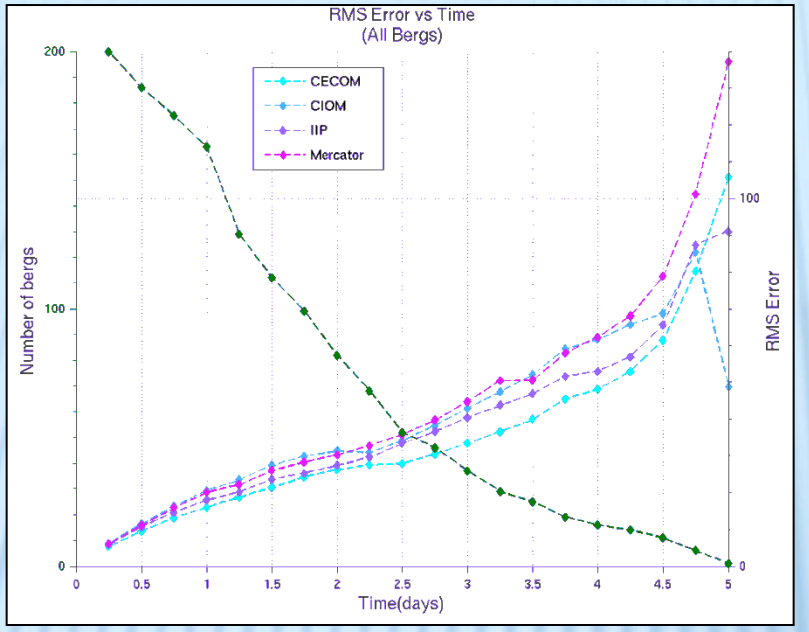
WHAT I AM LACKING/ CHALLENGES

More observations, especially concerning iceberg deterioration and related processes

Critical mass involving a variety of interested parties

More funding would always be nice

IMAGE OR ILLUSTRATION



Accurate iceberg drift forecasts are crucially dependent on ocean current forecasts. Progress continues in this regard but accurate eddy resolving models will not be available any time soon. Probabilsitic forecasts are the way to go for EC while industry may want to focus on incorporating real time observations for short range forecasts

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Barker, A., M. Sayed, and T. Carrieres. 2004: Determination of Iceberg Draft, Mass and Cross-Sectional Areas. Proceedings ISOPE'04, Paper 2004-MS-02, Toulon, France.

Carrieres, T., M. Sayed, S. Savage and G. Crocker, 2001: Preliminary Verification of an Operational Iceberg Drift Model. Proceedings 16th International Conference on Port and Ocean Engineering under Arctic Conditions, POAC'01,pp 1107-1116, Ottawa, Canada.

Crawford, A. J., D. R. Mueller, E. R. Humphreys, T. Carrieres and H. Tran, 2015: Surface ablation model evaluation on a drifting ice island in the Canadian Arctic. Cold Regions Science and Technology, Volume 110, February 2015, Pages 170–182

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Savage, S.B., Crocker, G.B., Sayed, M., and Carrieres, T. 2001: Bergy bit and growler melt deterioration. Journal of Geophysical Research – Oceans, Vol. 106 (C6), pp.11,493-11,504.

WHO I AM

- *Amec Foster Wheeler, St. John's NL*
- *weather forecasting, physical oceanography, met-ocean monitoring, information management*
  - *John McClintock, senior marine scientist, ice management*
  - *Terry Bullock, senior forecaster, ice management*
  - *Michael Abbott, wind energy assessment, Arctic R&D Step-Up integrated ice system: surveillance, forecasting, risk assessment*
  - *Jonas Roberts, PhD in civil engineering, hydrological impacts of climate change*
- *service providers, researchers*

INTERESTS

1. *Integrated ice surveillance system that incorporates risk assessment, iceberg and sea ice remote sensing technology, and ice forecasting technology (Statoil, RDC)*
2. *Ice management: plans, operations*
3. *Availability of data consistent with defined standards (e.g., GML, MANICE)*
4. *Improved met-ocean data for regions where ice is prevalent*
5. *Iceberg databases: climatology, ice management, improved characterization of ice observations (more than location, size, shape)*
6. *Global climate change: sea ice conditions, iceberg populations*
7. *Oil spill in ice*

MOST PRESSING GAPS

1. *Ocean Current Data for Improved Iceberg Trajectory Forecasting – though operator data are being provided to EC*
2. *Iceberg detection, e.g., ground truth of satellite iceberg detection*
3. *Enhanced Sea Ice Monitoring – thickness, drift, features*

WHAT I AM OFFERING

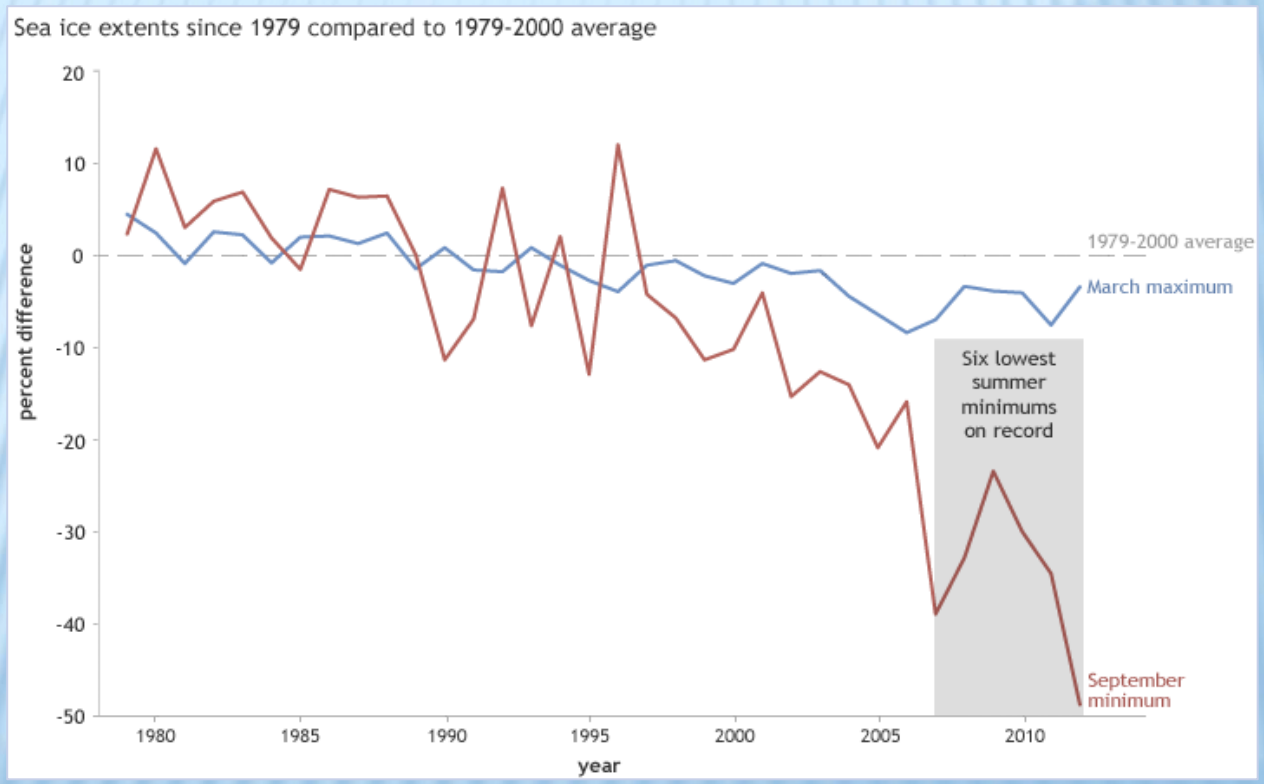
1. *Ice management experience,*
2. *Met-ocean monitoring – buoys, ADCPs, met stations – and modelling*
3. *High resolution weather forecasting*
4. *Potential synergies with East Coast oil & gas operators (our clients)*

WHAT I AM LACKING/ CHALLENGES

1. *Remote sensing information*
2. *Ice mechanics*
3. *Sea ice experience*

IMAGE OR ILLUSTRATION

"Overall, since satellite-based measurements began in the late 1970s, Arctic sea ice extent has decreased in all months and virtually all regions, with the exception of the Bering Sea during winter. The average melt rate in September is now -91,600 km^2 per year or -13% per decade relative to the 1979-2000 average. Summer ice declines have been especially rapid since 2001.



Source: Kennedy, C. 2013. State of the Climate: Arctic Sea Ice Retrieved from https://www.climate.gov/news-features/understanding-climate/2012-state-climate-arctic-sea-ice

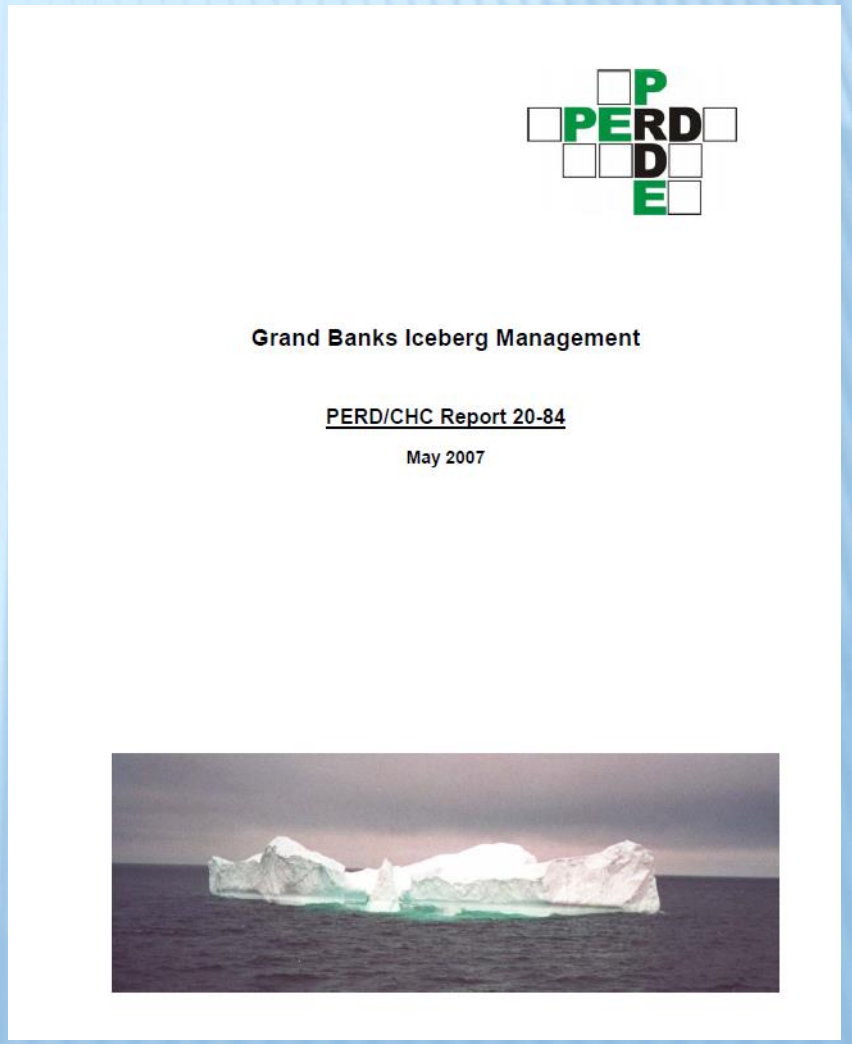
REFERENCES

General interest; topics: ice management, ice detection, ice towing, iceberg climate, issues for R&D

Team effort:

May 2007. "Grand Banks Iceberg Management." PERD/CHC Report 20-84. Report prepared for PERD/CHC, National Research Council Canada, Ottawa, ON. Report prepared by AMEC Earth & Environmental, St. John's, NL, R.F. McKenna & Associates, Wakefield, QC, and PETRA International Ltd., Cupids, NL.

Google - nrc perd grand banks iceberg management



WHO I AM

Carrie Young, Shore Base Manager, HSEQ Lead, Provincial Aerospace, Aerospace Operations

13 years with PAL, worked both onshore and offshore as an Ice and Environmental Specialist

PAL is a combination of researcher, end user, service provider, and data source.

Provincial Aerospace

INTERESTS

- *Improved short term iceberg drift forecasting*
- *Seasonal iceberg concentration forecasting for multiple regions*
- *Ensemble forecasting of iceberg drift*
- *Forecasting of large calving events*
- *Aerial drop products to enhance upstream iceberg tracking*
- *Iceberg management in sea ice*
- *Iceberg management to support 3D seismic*

Provincial Aerospace

MOST PRESSING GAPS

- *Accurate iceberg drift forecasting up to 48 hours*
- *Seasonal iceberg forecasts for multiple regions*

Provincial Aerospace

WHAT I AM OFFERING

- *Aerial reconnaissance data collection program*
- *Nearly 40 years experience in operational ice management support spanning multiple clients and multiple regions*
- *Aerospace - Mission Systems and Integration*
- *Maritime Domain awareness*

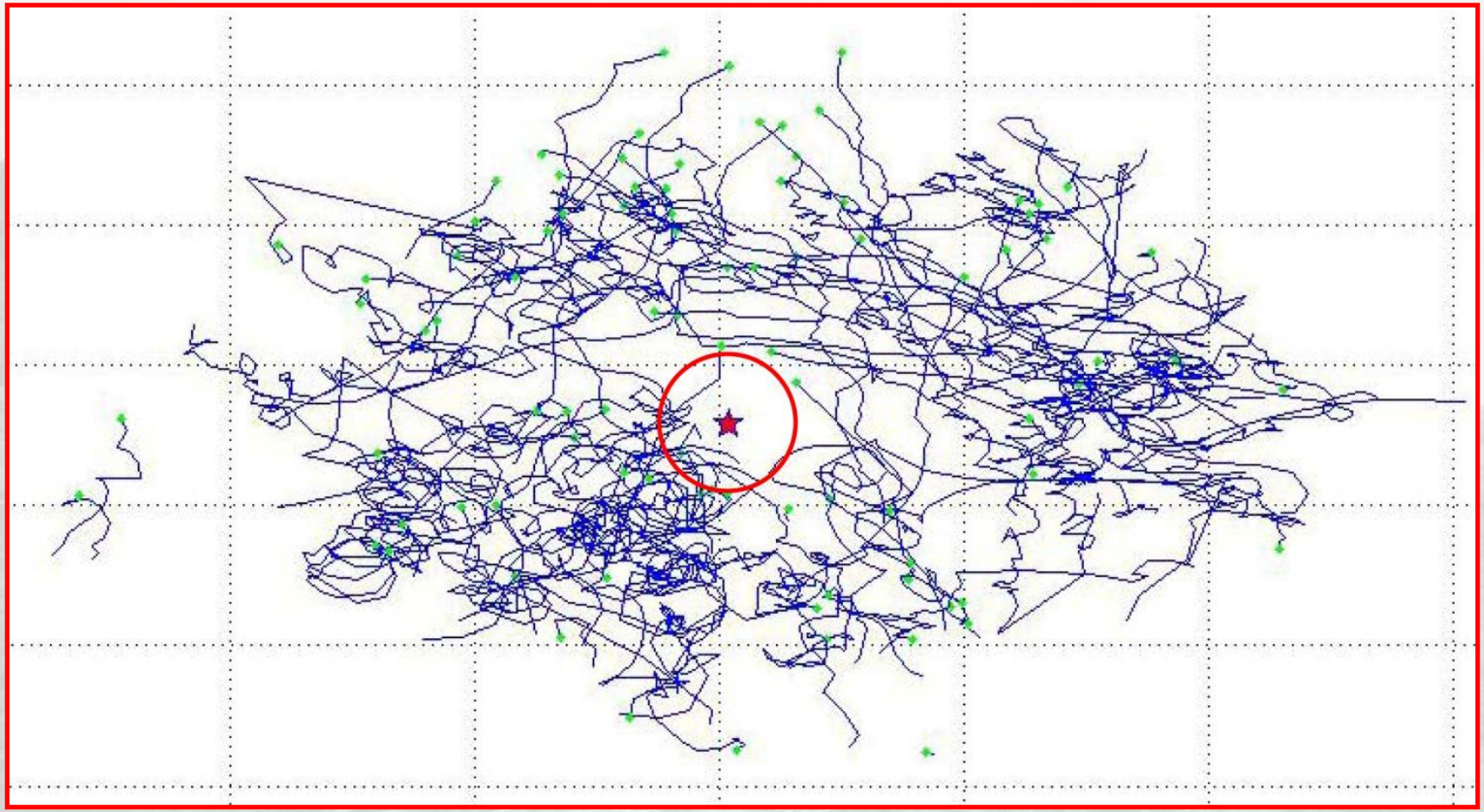
Provincial Aerospace

WHAT I AM LACKING/ CHALLENGES

- *Reliable ocean current models*
- *Multiple real time ocean currents in the operational areas where icebergs drift*
- *Seasonal forecasting (prevailing winds, ocean currents and temperatures)*

Provincial Aerospace

IMAGE OR ILLUSTRATION



Provincial Aerospace

WHO I AM

I'm Hai Tran, a Sea Ice and Iceberg Modeller at CIS for more than 17 years.

Take care of operational CIS CIOM EC, CECOM and Iceberg model.

I provide Sea Ice and Iceberg model output for CIS forecasters, Iceberg output for CCORE and PAL. I also provide Ice Island model results to researchers when needed

INTERESTS

Would like to improve the Sea Ice and Iceberg model output by obtaining In Situ observed Ocean Current and/or Wind data where and when the icebergs /Ice Islands are observed

MOST PRESSING GAPS

Lack of in situ measurement of ocean currents

Lack of observed wind data

Communication between end users and researchers and providers

WHAT I AM OFFERING

As a Sea Ice and Iceberg/Ice island modeller, I'm willing to help end users/researchers model outputs when needed

WHAT I AM LACKING/ CHALLENGES

Since the CIS iceberg/ice island model is a quite new and far from perfect. We did receive some of observed icebergs/ice islands tracks however the causes of model discrepancy is not clear unless we can obtain some ocean current (from surface to 200 m) and/or wind data so that we can tune the model.

WHO I AM

Claude Daley, D.Sc., FEC, P.Eng.
Professor Ocean Engineering
Memorial University
cdaley@mun.ca

Background: Western, Princeton, Helsinki, Arctec Canada

Core Skills: Ship Structures, Ice Loads, Simulation, Standards Development

Key Projects: ASPPR Rules, Polar Sea Loads, IACS Polar Rules, STePS2

I'm a researcher.

MEMORIAL UNIVERSITY

INTERESTS

My interests are:

- *The nature of the ice/structure impact from an Engineering Design perspective*
- *The definition of structural design objectives.*
- *Overload response to ice*
- *The physical parameters that influence load/response*

MEMORIAL UNIVERSITY

MOST PRESSING GAPS

*The key gap that interests me is the understanding of the **mechanical basis of extreme structural responses to ice**. I believe that the extreme responses depend on complex non-linear mechanics, and are inadequately treated by currently available methods (statistical approaches don't work).*

Key hard topics:

- *Theory of extremes in highly non-linear systems*
- *Predicting the no Fracture/Fracture boundary*

MEMORIAL UNIVERSITY

WHAT I MIGHT OFFER

skills, equipment, knowledge, data or resources:

- ***Labs at Memorial (ice mechanics, structures)***
  - *Large Double Pendulum*
  - *Moving Load Apparatus*
  - *Ice Cone testing experience*
  - *Grillage testing experience*
- ***Simulation Experience (LS Dyna, GEM)***

MEMORIAL UNIVERSITY

WHAT I AM LACKING/ CHALLENGES

#1,2 – money and time

#3 – a lab that can apply a 50MN ice load

#4 – a group of programmers that well understand mechanics and can develop efficient massively parallel algorithms of the mechanics

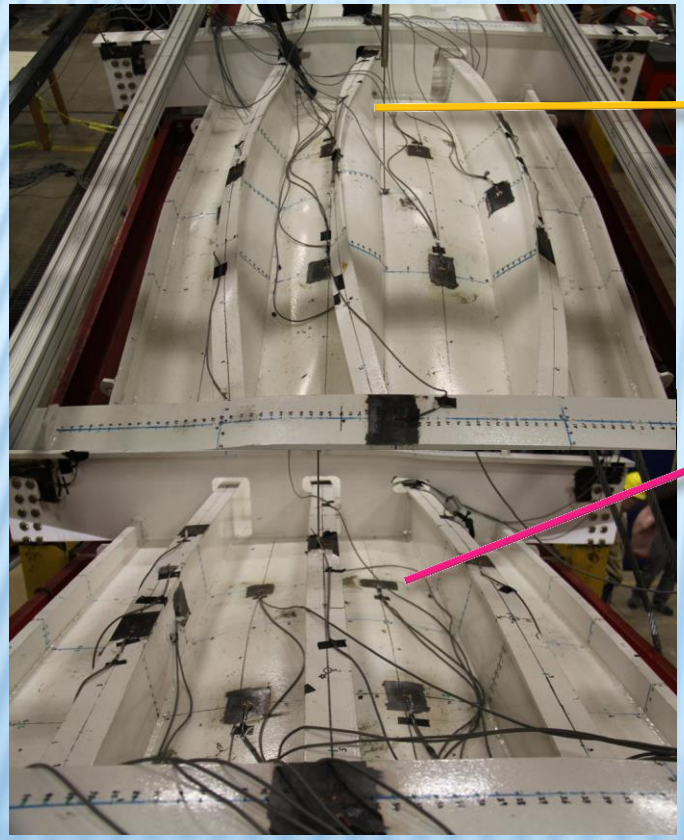
#5 – a client prepared to let me design a new generation of ice class structures and shipyard prepared to build them.

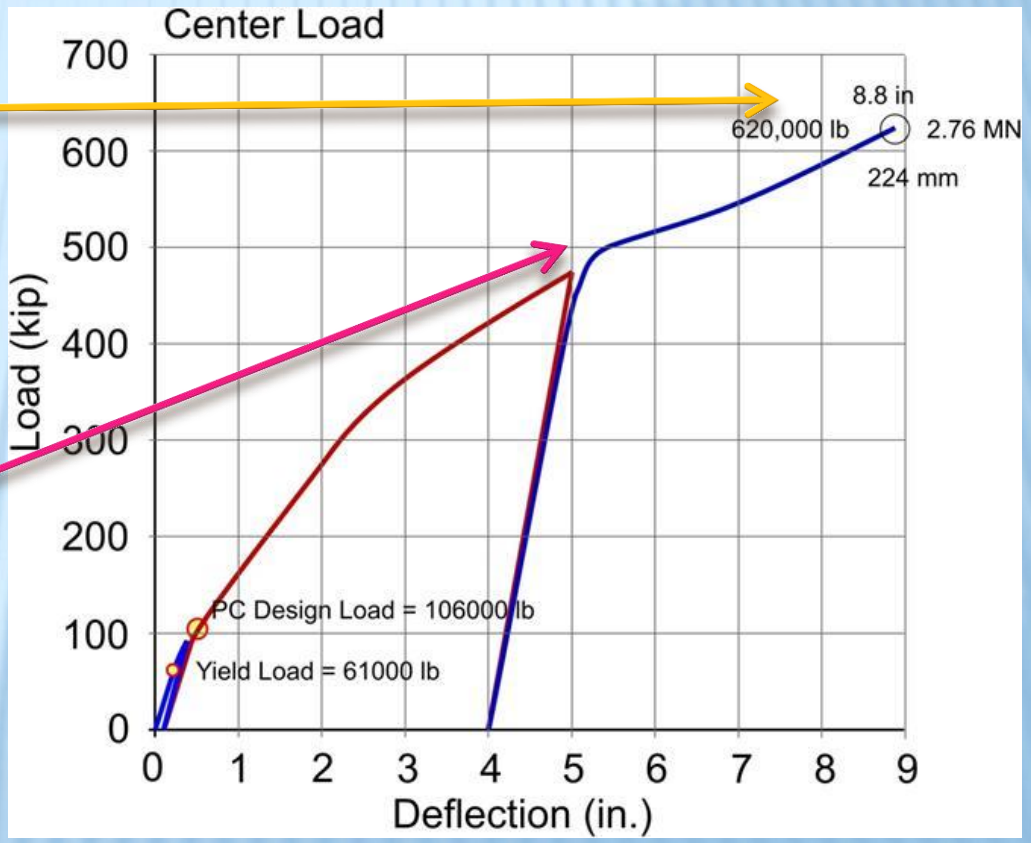
#6 – lots of fairy dust

MEMORIAL UNIVERSITY

ILLUSTRATION

- Ship Grillage can withstand 10x yield, 6x PC load,
- with minor effect (dent but no fracture)
- true limit not reached





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REFERENCES (THREE EXAMPLES)

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Dolny, J., Yu, H-C., Daley, C., Kendrick, A.,(2013) "Developing a Technical Methodology for the Evaluation of Safe Operating Speeds in Various Ice Conditions", Proceedings of the 22nd International Conference on Port and Ocean Engineering under Arctic Conditions , June 9-13, Espoo, Finland

Manuel, M., Reddy, P.S., Daley, C., Colbourne, B., (2013) "Controlled Plastic Deformation of a Grillage Using Artificial Freshwater Ice at a Large Scale" Proceedings of the 22nd International Conference on Port and Ocean Engineering under Arctic Conditions , June 9-13, Espoo, Finland

MEMORIAL UNIVERSITY

WHO WE ARE

Canatec Associates International Ltd. (Calgary, St. John's, Den Haag), represented by:

- *Chris Hill - 30 years ice imagery analysis, 10 years ice software development, 5 years ice instrumentation in all global ice zones*
- *Greg Warbanski –30 years offshore operations in E Coast Canada and Caspian Sea. 15 years ice/iceberg management.*

INTERESTS

Safe, efficient, environmentally responsible operations in sea and glacial ice zones:

- *Consulting Services:*
  - *Ice environment data acquisition and analysis*
  - *Operations planning*
  - *Design criteria for offshore structures and vessels*
  - *Identifying, tracking and forecasting decay and drift of hazardous ice features*
  - *Ice management and emergency response*
- *Field services*
  - *Services onboard vessels & structures to ensure operations executed within specs*
- *Training*
  - *Ice Advisors and Observers*
- *Products*
  - *Software for drift forecasting, ice atlas and site-specific ice charting*
  - *integrated software/instrument system to improve decision-making during operations in ice*
  - *UAV sensor system for ice reconnaissance*
  - *Ice drift tracking system, with airworthy-certified safe beacon deployment, and air-deployable beacons, ice-water interface, refreeze, UAV deployments and tracking oil spills in ice*

MOST PRESSING GAPS

Operations in ice are not using best possible technology/products; Canadians provide too little of the knowledge and products needed in this frontier industrial area.

Improvements are needed in:

- *Integrated decision-support systems to operate in ice*
- *Computer aided detection/analysis of ice features*
- *Integrated sensor systems and robotic delivery platforms*
- *Training and standards for Ice Advisors and Observers*

WHAT WE OFFER

- *Deep knowledge of offshore and marine industry requirements and processes*
- *Contacts to global expertise in ice operations*
- *24/7/365 operational readiness*
- *Development and sale of ice instrumentation and software*
- *Access to ice operations testing on our icebreaker (if bid, currently in evaluation, wins)*

CHALLENGE AND ACTION

- *To be useful, knowledge must be embodied in people, processes and products to make operations in ice safer and more efficient.*
- *The innovation system in Canada is weak (outside NL) in supporting research groups, technology companies and industrial users working together, to ensure the best knowledge is generated, people are trained, regulations are appropriate, products are available and Canadian companies prosper.*
- *This forum should help build a Canadian ice operations innovation system, starting with the participants.*

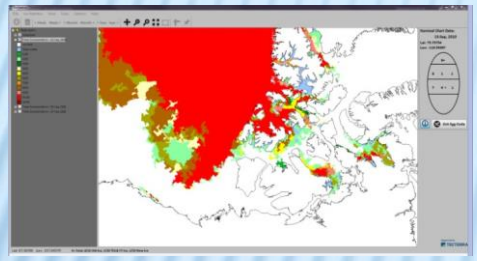
PARTIAL PORTFOLIO

Canatec's instrument development team in St. John's

Canatec Ice Drift Tracking Beacon

Airworthy-certified beacon deployment system

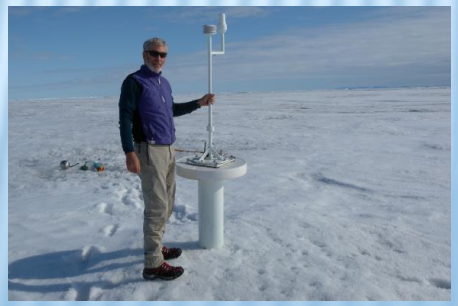
Ice Atlas



Test of UAV deployed beacon on iceberg

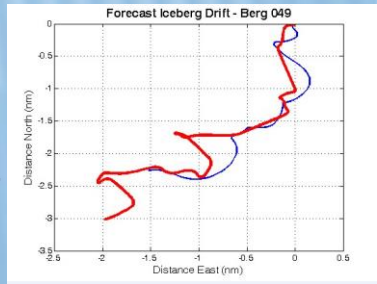
Onboard the Odin doing iceberg drift research off NE Greenland

UAV carrying optical, thermal, lidar sensors over simulated iceberg



Instrumenting an Ice Island off Ellesmere

Output from iceberg drift forecast software



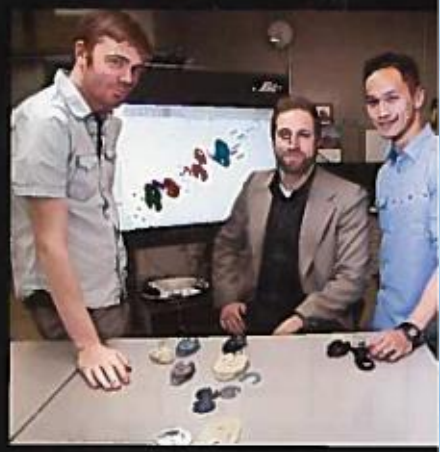
REFERENCES

Most Canatec consulting and field operation support work is industry confidential (eg 6 continuous years of gathering and analysing ice island drift data).

Opposite, an NSERC-supported project Canatec undertook with SAIT Polytechnic

INNOVATION

PUTTING A CLIENT'S WORRIES ON ICE



(Left to right) Principal Investigator Brian Hughes, Canatec's Chris Ulan-Kvitberg and student Timothy Huynh have designed a mechanism that efficiently releases ice beacons from their parachutes.

CHALLENGE: FOR CANATEC, HITTING THE TARGET WAS ONLY HALF THE BATTLE.

In providing analysis, forecasting and management of sea ice for industry, government and university researchers, Canatec drops plenty of ice-tracking beacons out of small aircraft in the high Arctic. But if the parachute doesn't detach from the beacon once it lands on an ice floe, an errant gust of wind can drag the entire assembly into the ocean – and the mission, so to speak, is sunk.

SOLUTION: CANATEC REPRESENTATIVES CONTACTED SAIT POLYTECHNIC'S APPLIED RESEARCH AND INNOVATION SERVICES (ARIS) DEPARTMENT IN EARLY 2014, AWARE OF SAIT'S TRACK RECORD IN THE AREA OF TECHNOLOGICAL DEVELOPMENT AND INDUSTRY PARTNERSHIP.

"Canatec is a Calgary company, and has been around for nearly 30 years. We knew about SAIT, we knew what they could do, and it seemed like a good fit for the type of work we needed done," says Chris Ulan-Kvitberg, Canatec's ice, structures and safety system specialist.

Having previously used small pyrotechnic devices to detach parachutes, Canatec approached ARIS Technology student Timothy Huynh – and five months later, SAIT's solution was signed, sealed and delivered.

"My inspiration actually came from the mechanism of a ballpoint pen, which is locked in one position and released in the other," says Huynh.

Loosely resembling a large padlock, Huynh's chute-release mechanism consists of sheets of aluminum and a two-stage spring mechanism. When the beacon is tossed out of a plane and the parachute opens, the tension in the line ensures the mechanism is locked in place; when the beacon lands on the ice and the tension in the line drops, springs rotate the centre plate and the parachute line is disconnected.

The ARIS team moved from plastic to steel to aluminum, used on-site 3-D printing and metal working facilities, and went through about a half-dozen significant design changes before presenting a final design ready for mass production.

That design was put through its paces at the Beiseker airport, and "they succeeded exactly as we predicted, which is really reaffirming," says

This past spring, Canatec deploying the chute-release mec in the far North. And a satisfied customer, apparently, is a repeat customer.

The project is expected to run through mid-2016, and will involve ARIS know-how in the areas of design, fabrication and injection molding.

"I like the practicality of SAIT. I like the fact that they have not only the academic skills, but the technical proficiency to understand materials, fabrication processes, and the limitations of designs and materials," says Ulan-Kvitberg.

through the build, the analysis and the final product."

ASL Environmental Sciences

Howard Edel*, ASL, Technical Marketing (retired from DFO HQ)

Kaan Ersahin, ASL, Radar Remote Sensing Scientist, RS Group Manager

David Fissel, ASL, Senior Scientist / Oceanographer, Board Chair

(ASL roles: Researcher / Service Provider / Data Source)

Glacial Ice Hazards Working Group Inaugural Meeting

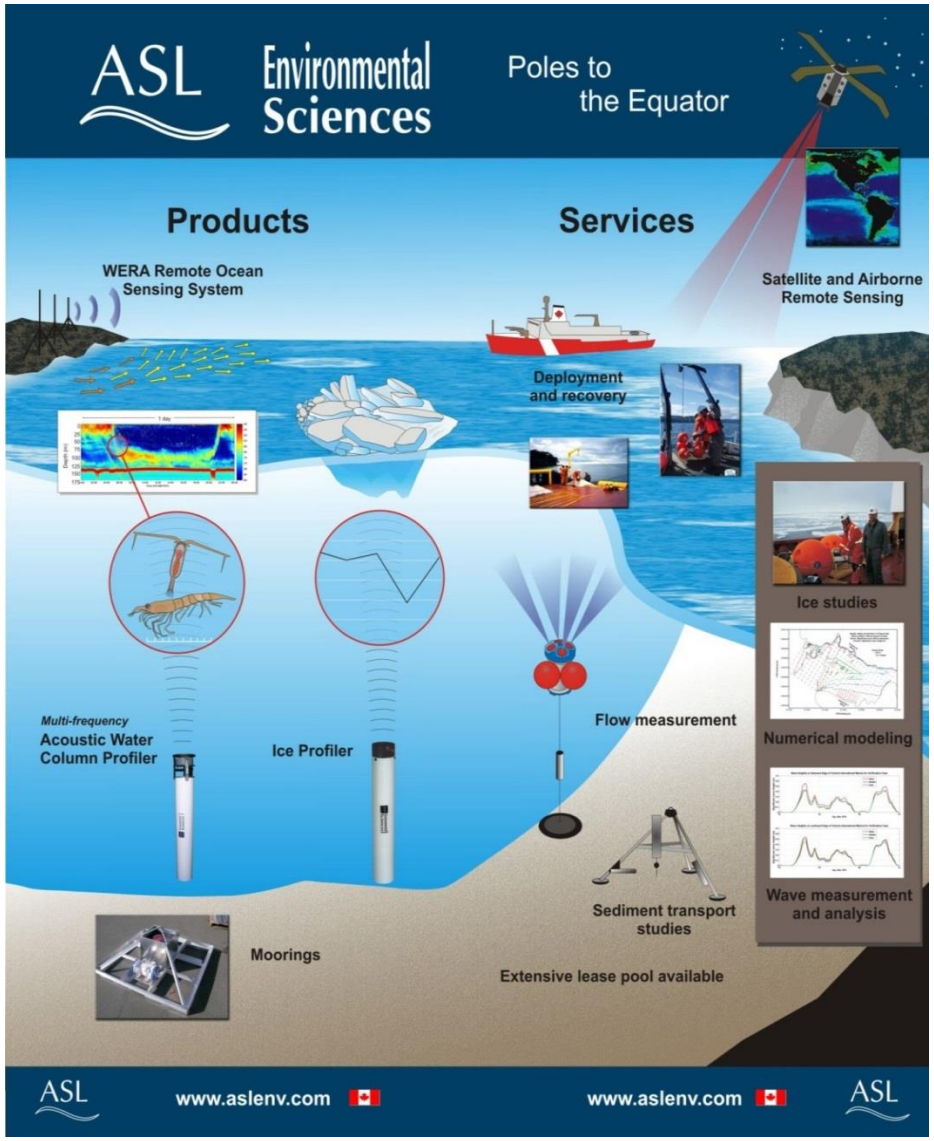
25-26 June 2015

Carleton University, Ottawa

Aquatic Services and Products

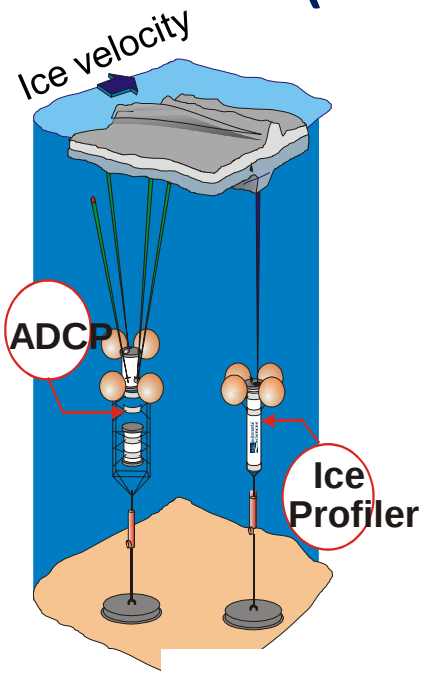
- Acoustic instruments
  - Design and manufacturing
    - Ice Profiler (IPS, SWIP)
    - Acoustic Zooplankton and Fish Profiler (AZFP)
  - Underwater cabled observatories
    - VENUS, NEPTUNE (AZFP), CHARS (SWIP)
    - (Previously) Confederation Bridge (IPS)
  - Concept studies on gliders, AUVs
- Extensive field operations in the Arctic and other regions (Met-ocean surveys)
- Scientific research and data analysis
- Modelling (coastal ocean circulation)
- Remote Sensing and GIS*
- Oceanographic Equipment Leasing

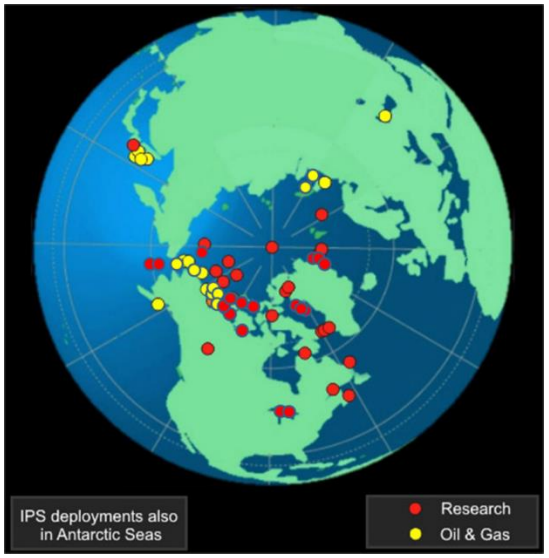
(*) Also terrestrial applications for mining, O&G, etc.)

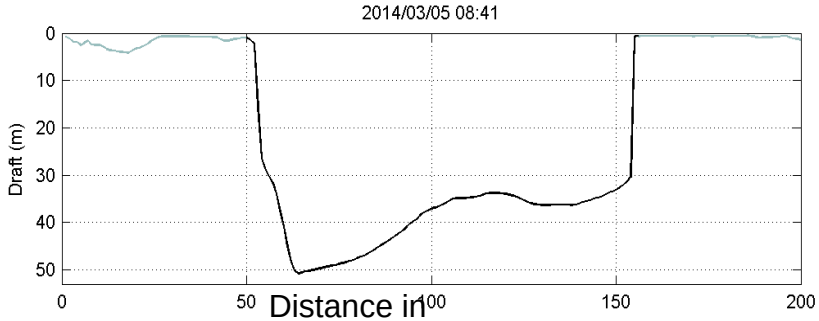


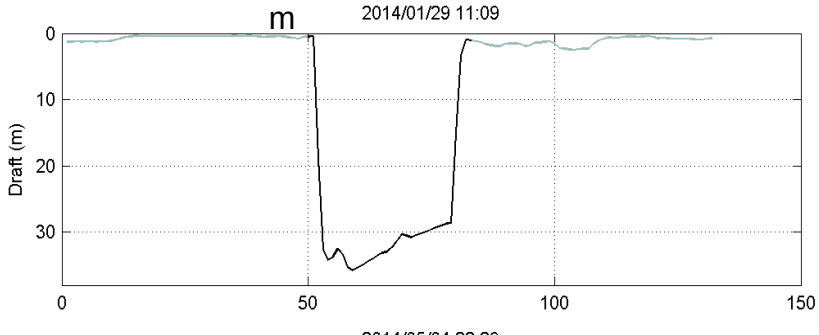
ASL Ice Profiler™ (IPS)

- More than 180 instruments
- Developed in collaboration with Dr. Humfrey Melling (IOS-DFO, Victoria BC)
- **ULS instrumentation (IPS+ADCP)** is used to continuously measure ice draft and characterize hazardous ice features (keels, hummocks, MYI, glacial ice)
- **Applications:**
  - Polar Science/Climate Studies
  - Offshore Oil and Gas Platform Design
  - Environmental assessment programs
- **ULS Measurements of Icebergs:**
  - Multiple Year-Long IPS Deployments in Baffin Bay, Labrador Sea, NE Greenland, Barents Sea
  - Measurement of Hundreds of Marine Glacial Ice Features:



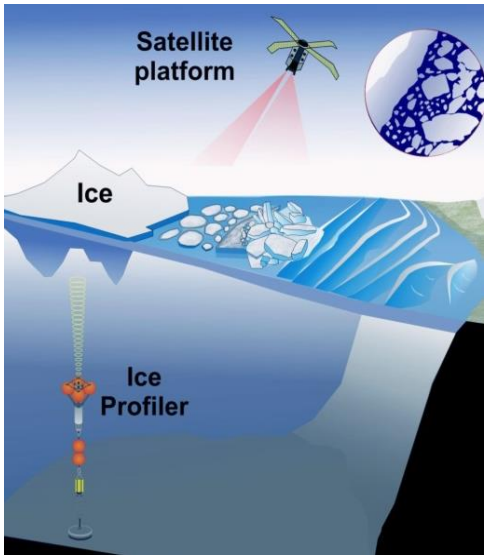






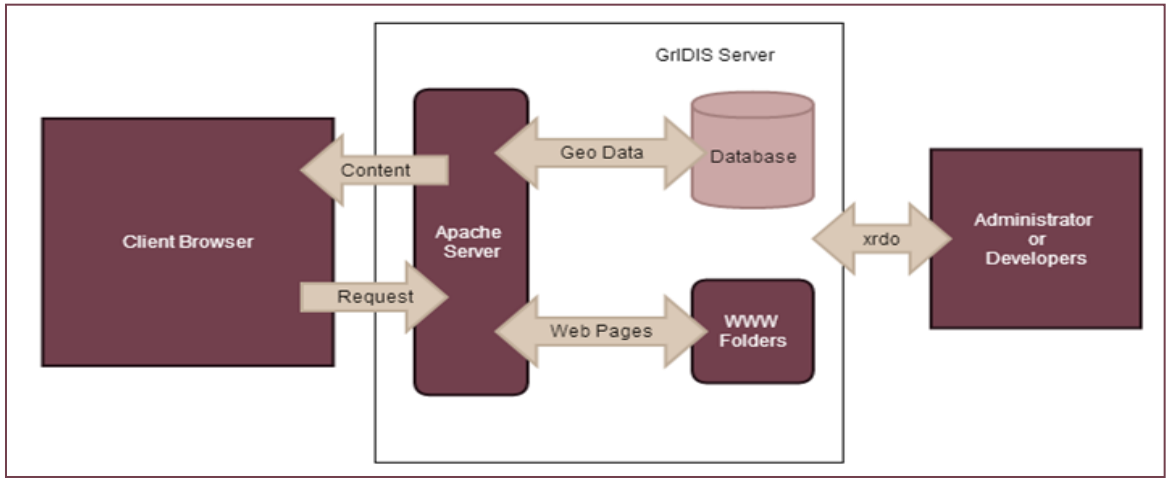
Characterization of Hazardous Ice Using RADARSAT-2 & ULS (CHOIRS)

- Funding (CSA EOADP: 2013-2015); Gov't Users (EC/CIS, NRC)
- Motivation: Need better characterization of hazardous sea ice features to support safe Arctic marine operations (Offshore O&G, Shipping, Coast Guard, Navy), and engineering design studies for coastal and offshore structures under Arctic conditions.
- Goal: Enhanced characterization of ice by combining "the view from above" (SAR) with "the view from below" (ULS)
- Results:
  - Methods for integrated analysis of ULS and satellite SAR data
  - ULS data and ice characterizations are used to validate polarimetric SAR algorithms for hazardous ice detection.
  - Assessment of ULS algorithms for MYI detection
  - Demonstrated new ice information products (e.g., SAR-based ice draft map, floe mass)
  - Simulated RCM compact polarimetry provided comparable performance to quad-pol.



Greenland Ice Data Interactive System (GrIDIS)

- Work Scope: Develop and maintain an online spatial database
- Users can retrieve information from the database and display results on map
- Authorized users can download the original datasets



Glacial Ice Information Service Challenges

- Select & implement marine reference sites for in-situ Glacial Ice reference data, including sites with near-real-time data access
- Define a suite of glacial information products to be developed and provided on a Portal dedicated to Glacial Ice Information
- Develop algorithms to predict concentration of annual spring ice bergs and hazardous ice in Davis Strait and south to oil production operations and vessel traffic
- Develop & validate algorithms to produce glacial ice information products from the RCM/SAR compact polarimetric data

Other Glacial Ice Issues to Address

- The continental Glacial Ice in the Canadian Rocky Mountains may need additional development projects (define ice pack parameters to be measured)
- The Prairie and British Columbia river flow rates and changes will need to be monitored with changing climate parameters
- Training ice analysts to identify hazardous ice features in the marine ice pack

About C-CORE

- Institute of Memorial University
- Independent Board of Directors
- Canadian not-for-profit corporation
- 95 staff in: St. John's, Ottawa, Halifax
- 10-15 students – tomorrow's HQPs
- Established in 1975 to address challenges to offshore O&G development in NL and other ice-prone regions
- Core skills in Remote Sensing, Ice Engineering and Geotechnical Engineering

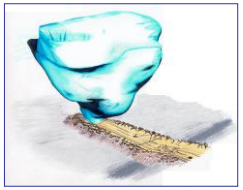
MEMORIAL UNIVERSITY

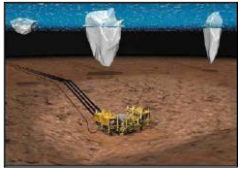
c-core

Integration of Expertise

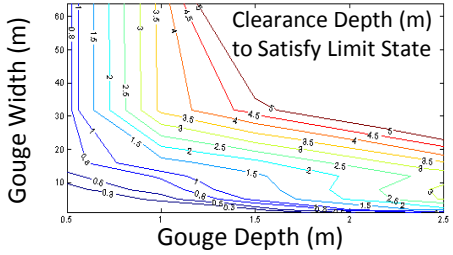
REMOTE SENSING

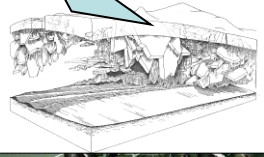
ICE ENGINEERING





GEOTECHNICAL ENGINEERING



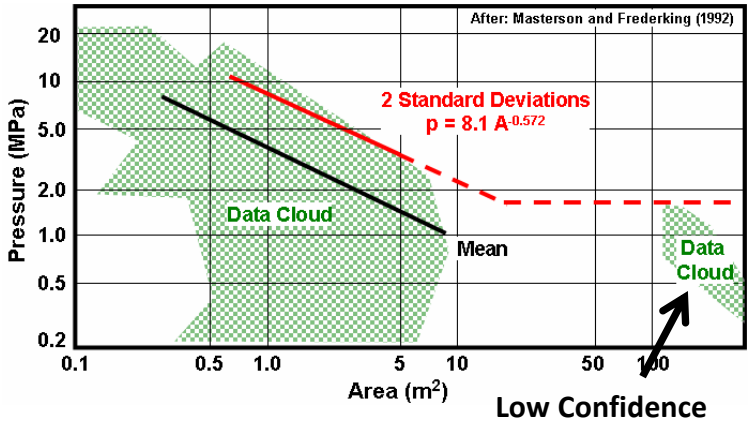


Most Pressing Gaps

- Uncertainty associated with ice loads on structures for large icebergs
- Ability to analyze (mine) satellite archives for ice information
- Ability to effectively analyze new courses of ice information (e.g., Sentinel, Planet Labs, RCM)
- Detection in high sea states

GAP: Large Scale ice crushing data

Require ice crushing pressures for large areas (10 – 100 m2) for use in offshore structure design (currently only limited, low confidence data)



What C-CORE Offers

- Collaborative project development
  - Building teams for collaborative R&D projects
- Experience in working with O&G industry and understanding/quantification of risk
- Ability to work with industry, governments and academia to common goals
- International Outreach

WHO I AM

Dr. Luke Copland (luke.copland@uottawa.ca)
University Research Chair in Glaciology
Department of Geography
University of Ottawa

Researcher
http://cryospheric.org

INTERESTS

- *Glacier dynamics*
- *Iceberg discharge rates*
- *Breakup and stability of Canadian Arctic ice shelves*
- *Iceberg tracking and detection*

MOST PRESSING GAPS

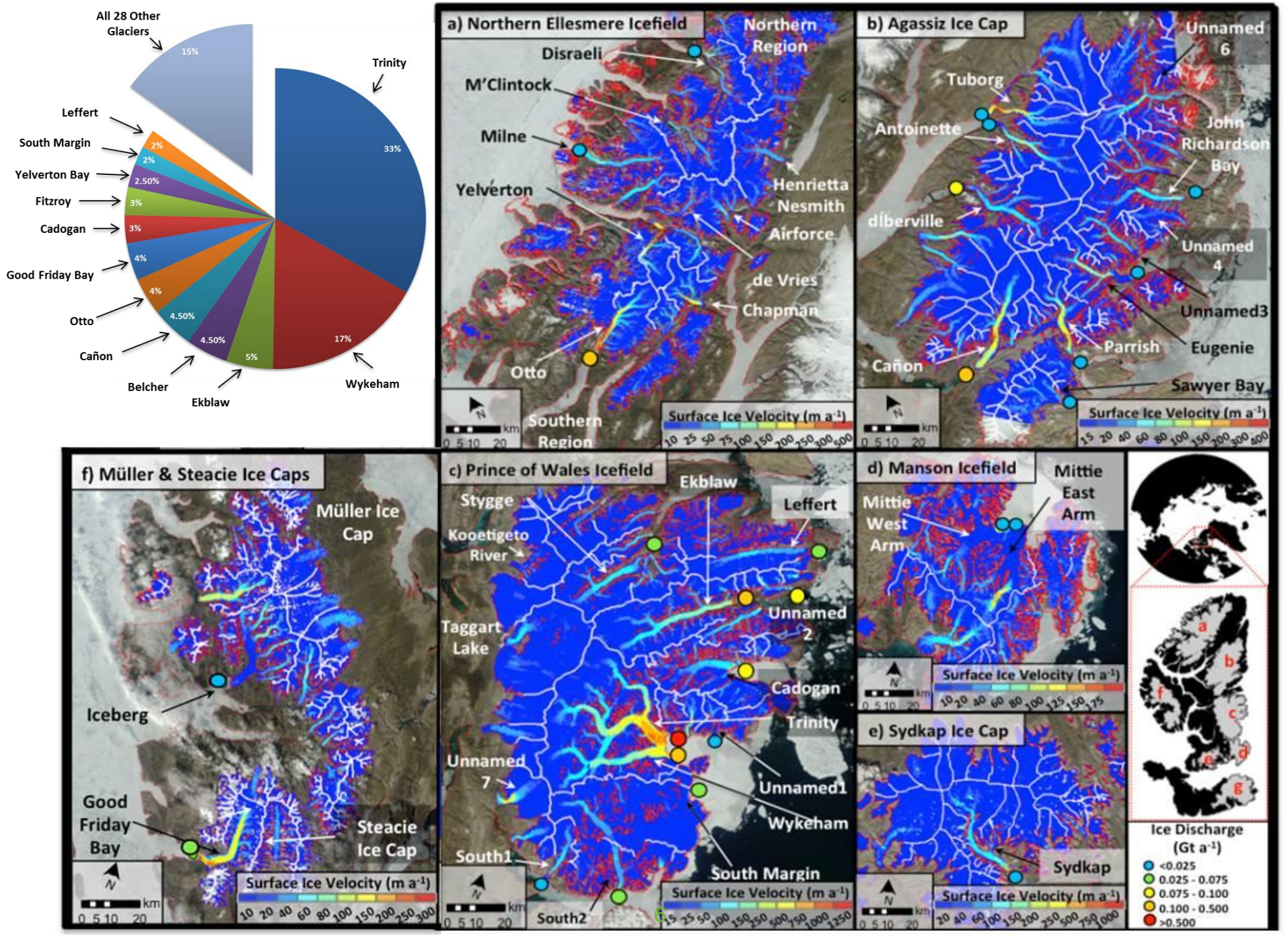
- *Where do icebergs originate from?*
  - *e.g., do icebergs in the Grand Banks originate from Canadian or Greenland glaciers?*
- *Is the rate of iceberg production changing over time?*
  - *E.g., connection to glacier and ice shelf losses?*
- *Can we better predict the number and distribution of icebergs months ahead of time?*

WHAT I AM OFFERING

- *Glacier velocities and iceberg discharge rates for all Canadian glaciers*
- *Field measurements of glacier and iceberg thicknesses (particularly for N. Ellesmere)*
- *Testing of algorithms for automated detection of icebergs in SAR imagery*

WHAT I AM LACKING/ CHALLENGES

- *Better access to high resolution SAR and optical remote sensing imagery*
- *Difficult and expensive access to field locations*
- *Lack of information on long-term (multi-year) iceberg tracks*


All 28 Other Glaciers
15%
Trinity
33%
Leffert
2%
South Margin
2%
Yelverton Bay
2.50%
Fitzroy
3%
Cadogan
3%
Good Friday Bay
4%
Otto
4%
Cañon
4.50%
Belcher
4.50%
Ekblaw
5%
Wykeham
17%
a) Northern Ellesmere Icefield
Northern Region
Disraeli
M'Clintock
Milne
Yelverton
Henrietta Nesmith
Airforce
de Vries
Chapman
Otto
Southern Region
Surface Ice Velocity (m a-1)
b) Agassiz Ice Cap
Unnamed 6
Tuborg
Antoinette
John Richardson Bay
diberville
Unnamed 4
Unnamed3
Parrish
Eugenie
Cañon
Sawyer Bay
Surface Ice Velocity (m a-1)
f) Müller & Steacie Ice Caps
Müller Ice Cap
Iceberg
Good Friday Bay
Steacie Ice Cap
Surface Ice Velocity (m a-1)
c) Prince of Wales Icefield
Ekblaw
Stygge
Leffert
Kooetigeto River
Unnamed 2
Taggart Lake
Cadogan
Trinity
Unnamed 7
Unnamed1
Wykeham
South1
South Margin
South2
Surface Ice Velocity (m a-1)
d) Manson Icefield
Mittie East Arm
Mittie West Arm
Surface Ice Velocity (m a-1)
e) Sydkap Ice Cap
Sydkap
Surface Ice Velocity (m a-1)
a
b
c
d
e
f
g
Ice Discharge (Gt a-1)
<0.025
0.025 - 0.075
0.075 - 0.100
0.100 - 0.500
>0.500

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- Mortimer, C., Copland, L. and Mueller, D. (2012): Volume and area changes of the Milne Ice Shelf, Ellesmere Island, Nunavut, Canada, since 1950. *Journal of Geophysical Research – Earth Surface*, 117

http://cryospheric.org/publications/

WHO I AM

Wesley Van Wychen (M.Sc., Ph.D. Candidate)

1) University of Ottawa

Laboratory for Cryospheric Research

2) Natural Resources Canada

Research interests in RADAR remote sensing and glaciology.

INTERESTS

My interests involve understanding how and why glacier dynamics and iceberg discharge varies over time. I also am interested in researching the calving process and using remote sensing methods to monitor and investigate these processes.

MOST PRESSING GAPS

We still have little understanding of the points of origin of icebergs within the Canadian Arctic and how these locations evolve over time.

WHAT I AM OFFERING

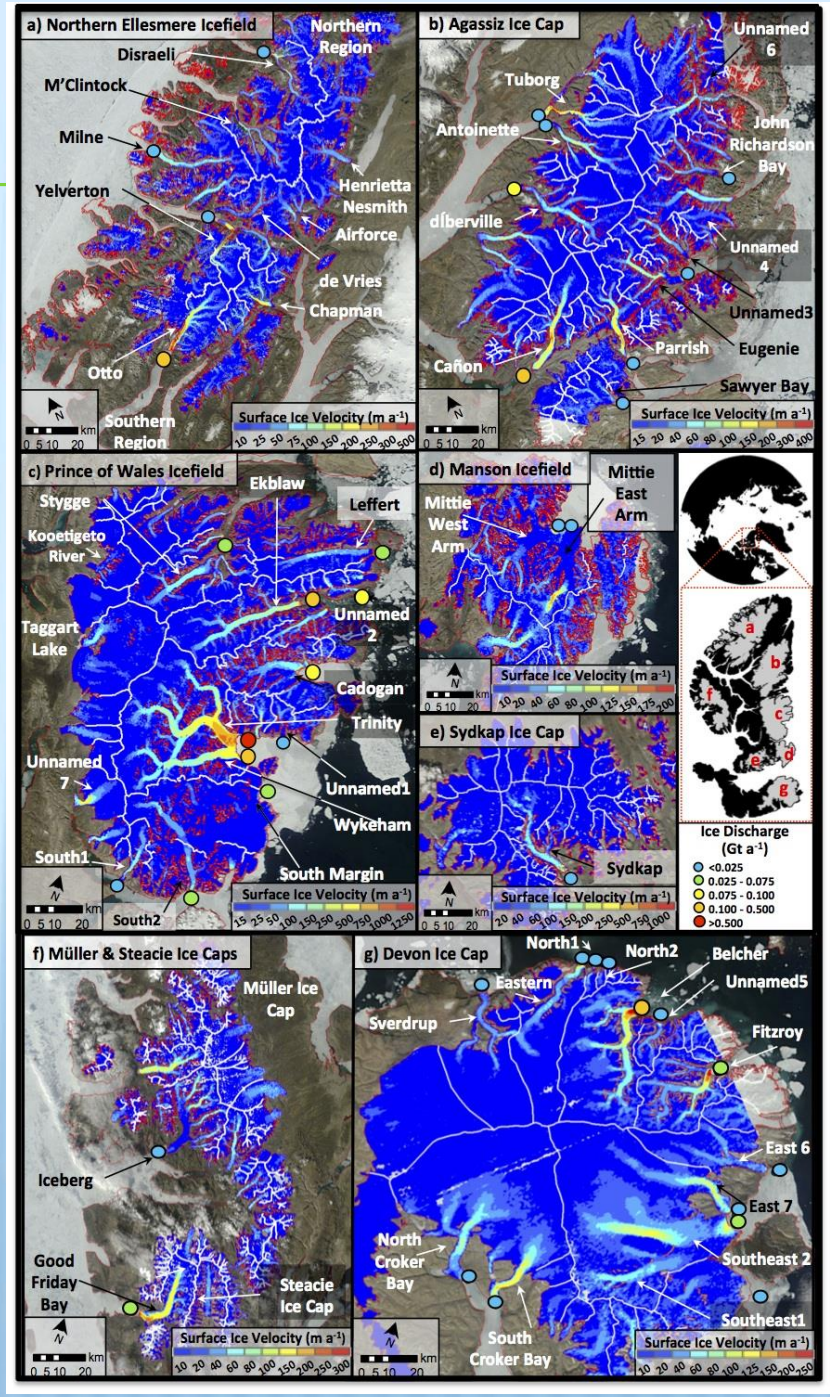
We now have a ~10-15 year record of ice motion and estimate of iceberg discharge for the major marine terminating glaciers within the Canadian Arctic derived from remote sensing datasets. This record will be updated annually in the near term.

WHAT I AM LACKING/ CHALLENGES

We still require good in situ observations both to validate our remote sensing datasets and to begin process based studies to understand the key factors (e.g. changes in sea ice conditions, ocean temperatures, enhanced glacier melt) that are driving changes in glacier dynamics, and iceberg discharge within the CAA.

IMAGE

Map of glacier ice flow and estimate of iceberg discharge for the major ice masses of the Queen Elizabeth Islands (Van Wychen et al., 2014, GRL).



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ICEBERG DISCHARGE FROM THE CAA

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- **Van Wychen, W.,** Copland, L., Gray, L., Burgess, D.O., Danielson, B. and Sharp, M. (2012). Spatial Variation of Ice Motion and Ice Flux from Devon Ice Cap, Nunavut Canada. *Journal of Glaciology*, **58:** 210. doi: 2012 doi: 10.3189/2012JoG11J164

ICE ISLANDS (DRIFT PATTERNS)

- **Van Wychen, W.,** and Copland, L. (Accepted July 9th, 2010 *30pp*). Ice Shelf Calving Events and Ice Island Drift Mechanisms in the Canadian High Arctic. Due for Publication in 2012. Copland, L. and Mueller, D. (eds). Arctic Ice Shelves and Ice Islands. *Springer-Verlag*.

WHO I AM

Derek Mueller

Dept. of Geography & Environmental Studies, Carleton University
Physical geography, glaciology, remote sensing and microbial ecology
Researcher

INTERESTS

Ice islands (primarily)… and icebergs (lately)
In the Arctic (preferably)… and East Coast (as it is more accessible)

Tracking with beacons and remote sensing
Detection with remote sensing (SAR)
Thickness measurements (Radar)
Surface deterioration and environmental conditions
Keel and sail deterioration using surveying techniques (multibeam, laser scanner, photogrammetry)
Under ice profiling (UAV)
Influence on water column and ecology
Modelling of deterioration (see job ad) and drift (coming soon)

MOST PRESSING GAPS

In situ observations are required to understand processes and improve models

WHAT I AM OFFERING

Field work

Automated observation systems

Canadian Ice Island Drift and Deterioration Database (CI2D3)

WHAT I AM LACKING/ CHALLENGES

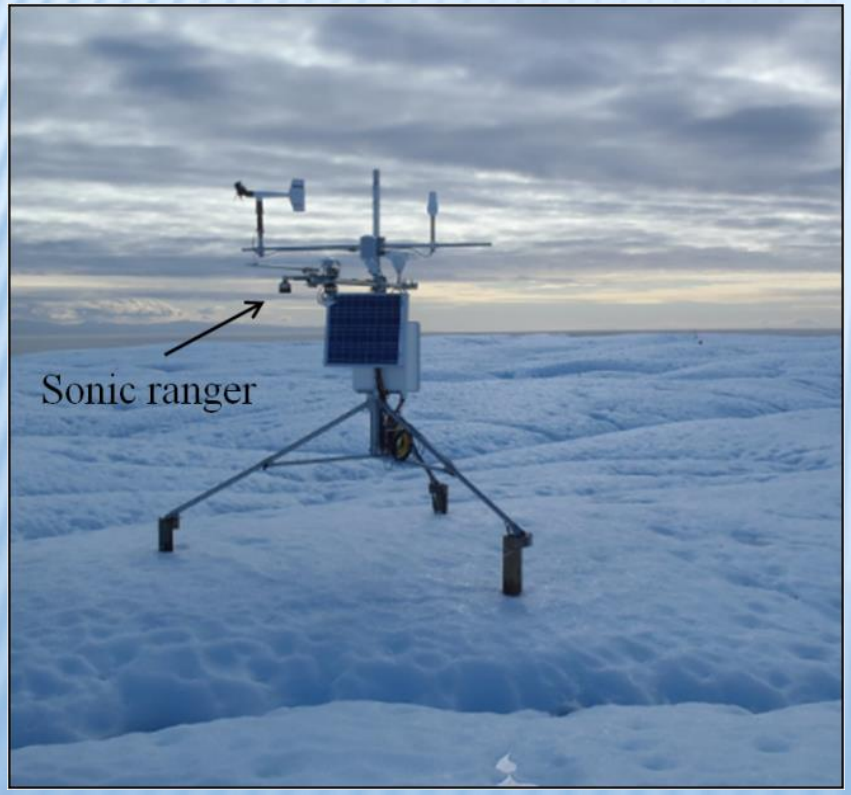
PhD student and Postdoc wanted for a modelling study

(*htp://wirl.carleton.ca/?p=688*)

Need $$ to fund in situ observations (transportation and equipment) – smaller vessel, longer dwell time

IMAGE OR ILLUSTRATION

- Thickness and environmental measurement examples



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Forrest, A.L., Hamilton, A.K., Schmidt, V., Laval, B.E., Mueller, D., Crawford, A., Brucker, S., and Hamilton, T. (2012) Digital terrain mapping of Petermann Ice Island fragments in the Canadian High Arctic. Proceedings of the 21st IAHR, Dalian, China, June 11-15, 2012, 710-721.

WHO I AM

Anna Crawford

Water and Ice Research Lab, Carleton U. HBSc Biology, MSc Geography

Field campaign organization and execution; ice island deterioration analysis

Researcher (PhD Candidate) & end user

INTERESTS

Ice island deterioration in eastern Canada

1) Vertical deterioration: modeling and remote detection

2) Horizontal (areal) deterioration: field detection

3) Horizontal (areal) deterioration: large scale fracture and occurrence patterns

MOST PRESSING GAPS

*1) **Field data collection** for development and validation of **remote detection & monitoring techniques** + **forecasting methods***

*2) **Novel methods** for **detecting deterioration***

- *Remote and field*

*3) **Prediction** of large scale **fracture***

WHAT I AM OFFERING

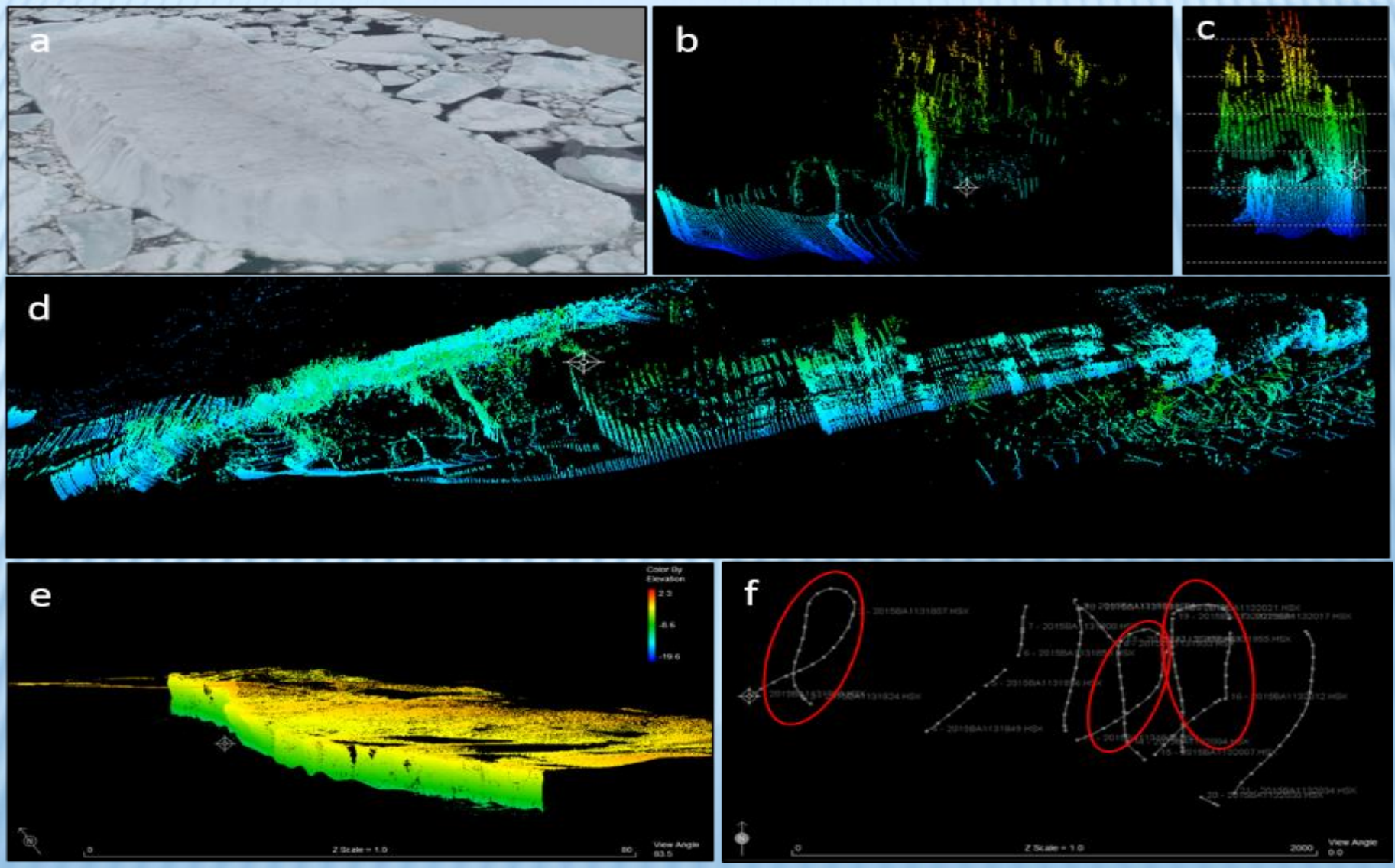
- ***Field campaign organization and execution*** *(IPR, AWS, photogrammetry, laser scanning)*
- *Histories of* ***Petermann ice islands***
- *Basic computer programming (R)*
- *Basic GIS skills*
- *Basic modeling skills*
- *Write-up*

WHAT I AM LACKING/ CHALLENGES

- ***Vertical*** *deterioration study:*
  - *Knowledge of* ***CryoSat-2*** *(TerraSAR-X/TanDEM-X?)*
  - ***Continuous*** **in-situ** ***thickness data*** *(*coming, but with challenges!
  - *Lack of* in-situ *data for* ***basal*** *melt modeling*

- ***Horizontal*** *deterioration study (local):*
  - *Sophisticated* ***computer programming*** *challenges*
  - ***Point cloud processing***

DATA COLLECTION – APRIL 2015



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WHO I AM

Greg Crocker, *Ballicater Consulting Ltd &*
DGES, Carleton University

- *PhD Scott Polar Research Institute (Cambridge)*
- *Director, Ice Engineering (C-CORE)*

INTERESTS

- *Iceberg/ice island*
  - *drift*
  - *deterioration*
  - *flux*
  - *risk*

MOST PRESSING GAPS

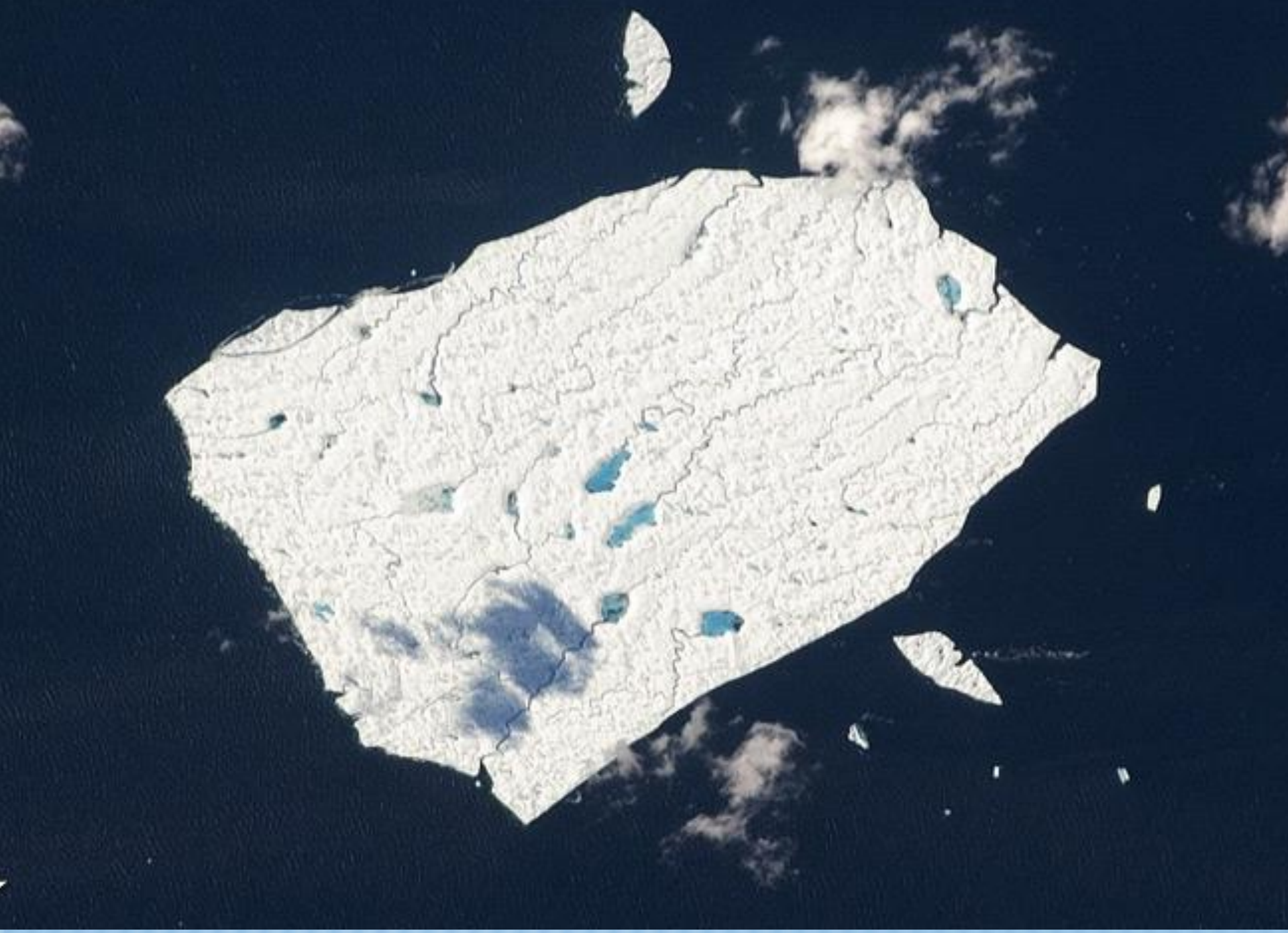
- *Ocean processes (when data are available) – improved drift forecasts, especially short term*
- *Ice island drift & deterioration – risk from large pieces and their children*

WHAT I AM OFFERING

- *Ice island drift/deterioration modelling*
- *Ensemble forecasting of iceberg drift*
- *Some new data (use would need to be negotiated with industry)*

WHAT I AM LACKING/ CHALLENGES

- *Deterioration data sets! (icebergs and ice islands)*



REFERENCES

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WHO I AM

Luc Desjardins

- *Carleton University contractor.*
- *Retired ice/iceberg forecaster for the Canadian Ice Service.*
- *Former provider of the Petermann Ice Island updates from CIS.*

Skill: Detecting and tracking ice island fragments on ScanSar-Wide radar images (R-1, R-2, Envisat).

Service provider: mainly image interpretation.

INTERESTS

Cycling, swimming, gardening , and

Establish the proper lineage of various ice island fragments in Canadian waters.

Share my expert knowledge gained while working at CIS on sea ice, iceberg, ice islands and modelling with this group.

MOST PRESSING GAPS

Lack of accurate ocean currents throughout a vast domain (resolution in the 10's of meters).

Large coverage of high resolution imagery for the detection, deterioration and forecast of ice hazards.

WHAT I AM OFFERING

Truthfully: Nothing…but,

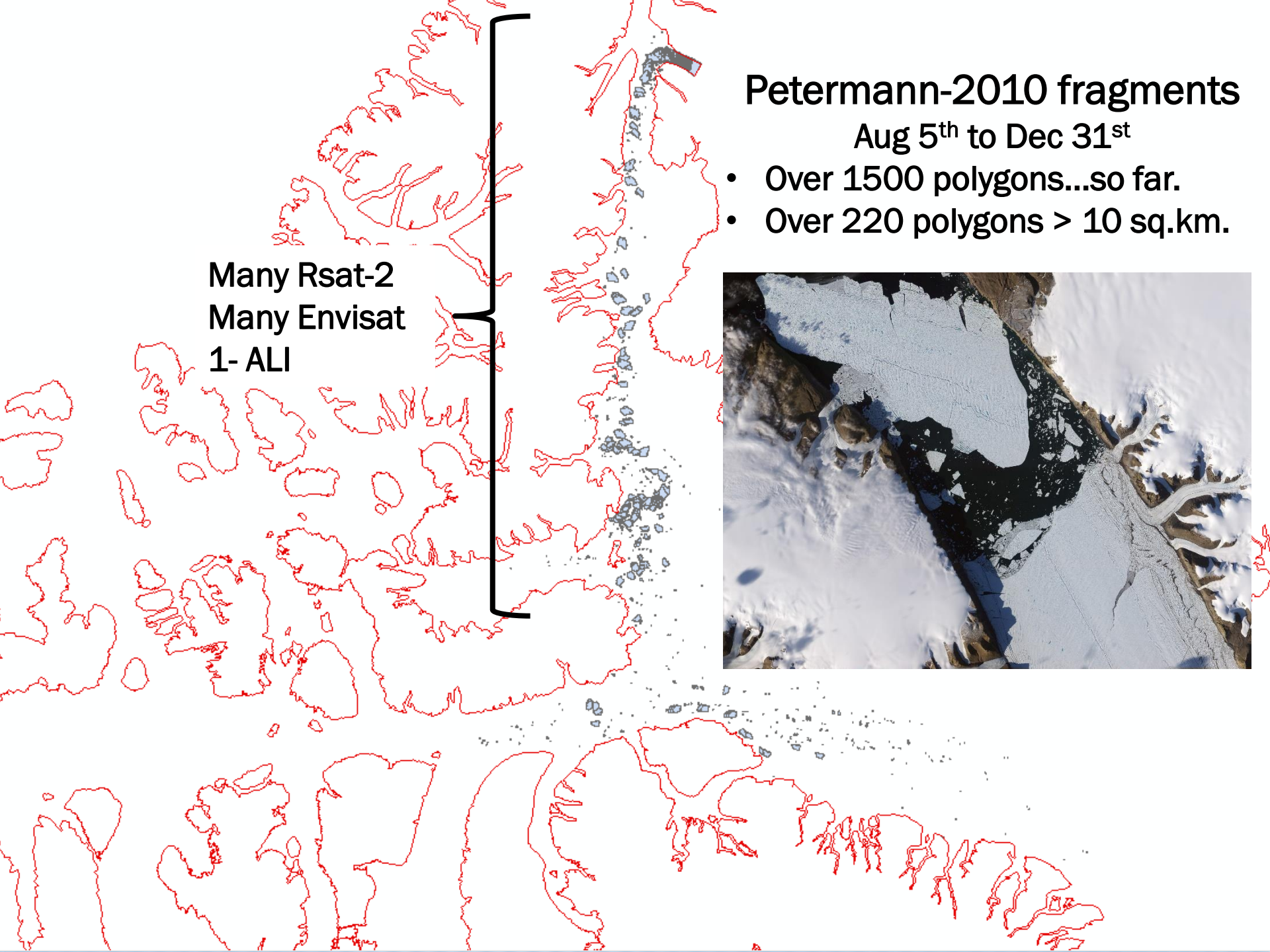
Willing to share my expert knowledge gained while working at CIS on sea ice, iceberg, ice islands and modelling with this group.

WHAT I AM LACKING/ CHALLENGES

Currently lacking: Nothing;

pleased with the way my retirement is going.

Challenges: keeping up with the work being done out there to better help this group.



Many Rsat-2
Many Envisat
1- ALI

Petermann-2010 fragments

Aug 5th to Dec 31st

- Over 1500 polygons…so far.
- Over 220 polygons > 10 sq.km.

REFERENCES

Sorry, none from me!

WHO I AM

Denise Sudom, B. Eng, Research Council Officer

National Research Council Canada, Ocean Coastal and River Engineering (NRC-OCRE)

I have worked on ice-related projects since 2002, including ice loads on offshore structures, field measurements and lab-based testing of ice properties, iceberg and sea ice forecasting, seabed scour or gouging by ice, offshore evacuation in ice-covered waters, ice in pipelines, and ice management.

Project engineer, researcher, end user, service and data provider

** Going on leave for one year; all inquiries should go to Philippe Lamontagne at NRC*

INTERESTS

- Iceberg data compilation:
  - Iceberg sightings off Canada's East Coast
  - Iceberg management operations
  - Measurements of iceberg geometries
- Data applications:
  - Iceberg forces on offshore structures
  - Seasonal iceberg severity prediction; correlation with (e.g.) sea ice extent and breakup date
  - Effectiveness and reliability of iceberg management techniques

MOST PRESSING GAPS

- Data availability due to confidentiality.
  Example: difficult to access new detailed iceberg geometries although new data has been collected for use by offshore operators.
- Consistency of iceberg sighting data and ability to use for statistical purposes.
  Example: analysing variability of iceberg counts from year to year; in some years more icebergs are detected because of more overflights, shipping traffic, offshore petroleum activity.

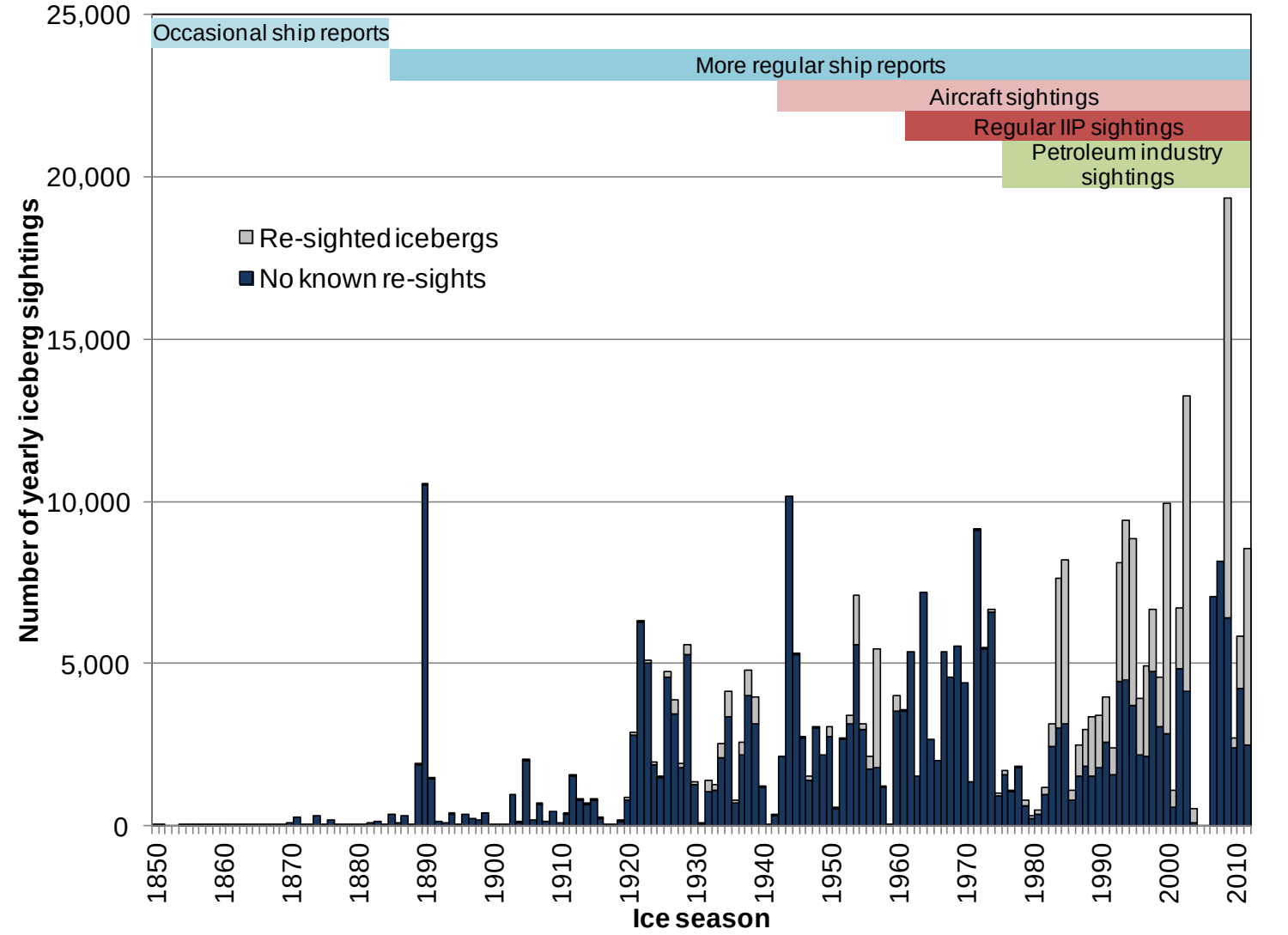
WHAT I AM OFFERING

- In the late 1990s, NRC, with the support of the Program of Energy Research and Development (PERD), began to work with both industry and the offshore regulators to develop and maintain industry standard databases on key iceberg information
- Three NRC-PERD Iceberg Databases are publicly available to interested stakeholders and researchers:
  - Iceberg Sightings (~405,000 data points)
  - Iceberg Shapes (~900 partial or full geometries)
  - Iceberg Management (~1,800 events)

WHAT I AM LACKING/ CHALLENGES

Databases are updated regularly; continually seeking new data on iceberg sightings, shapes or management for future addition

ICEBERG SIGHTINGS DATABASE



Reported iceberg sightings since the year 1850, and times during which various data sets are available.

Number of sightings increasing in recent years – *not the number of icebergs!*

REFERENCES

Sudom, Timco and Tivy (2014). “Iceberg sightings, shapes and management techniques for offshore Newfoundland and Labrador: Historical data and future applications”, Proceedings of OCEANS 2014 Conference, 14-19 September 2014, St. John’s, NL

WHO I AM

Matt Arkett, Remote Sensing Manager, Canadian Ice Service

CIS DUAP Project Mgr.

Researcher/service provider

INTERESTS

Here CONCISELY list your relevant interests. Be as specific as possible. Try to avoid listing generic topics.

- - Satellite detection/discrimination/characterization of icebergs, ice islands, ice hazards
- - Adapting research in these fields to operational application
- - New product development

MOST PRESSING GAPS

Within an identified context, what 2 or 3 max gaps are you aware of that are worthy of attention? Why do you think they are a high priority?

- - Continued advancements in detection/discrimination/characterization techniques
- - Improved modelling through assimilation of remote sensing data
- - Improved collaboration between academia, government and industry – finding solutions to common problems

WHAT I AM OFFERING

Describe what skills, equipment, knowledge, data or resources you could be willing to share if a mutually beneficial collaboration were defined with anyone.

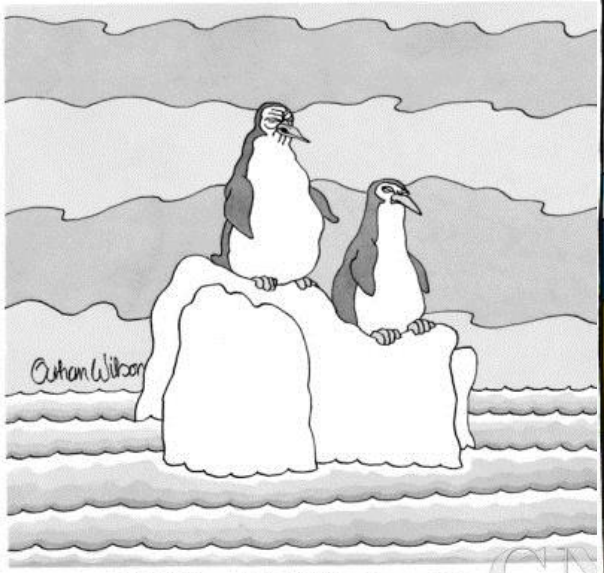
- - Imagery (within the confines of data policy agreements)
- - Possibly $$
- - Human resources

WHAT I AM LACKING/ CHALLENGES

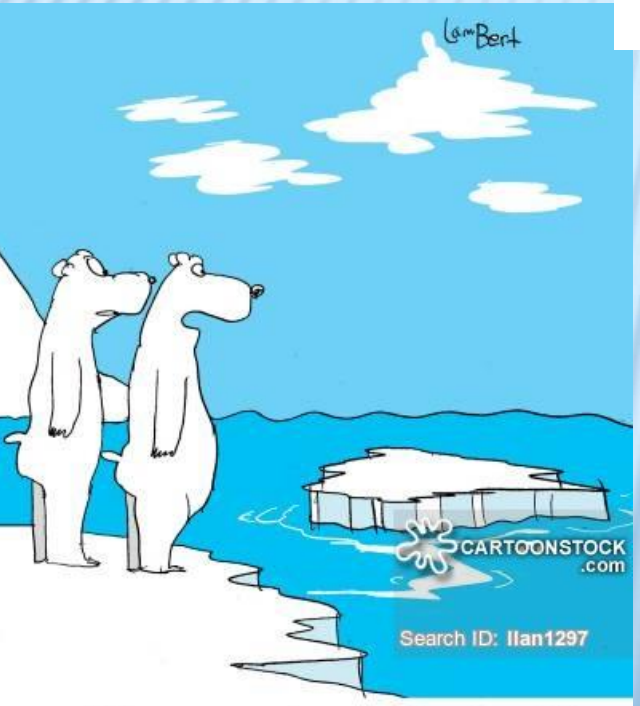
Describe what skills, equipment, knowledge, data or resources you need to address the gaps you perceive as most pressing. Describe any challenges.

- In situ validation data for icebergs and ice hazards, coincident with satellite overpasses

If Icebergs Dated



"Call this an iceberg? When I was a kid we wouldn't have called this an iceberg!"



"There goes the neighborhood."

REFERENCES

Provide a short bibliography of readings you feel would be helpful to other working group members in the context of your presentation.

WHO I AM

Abby Dalton

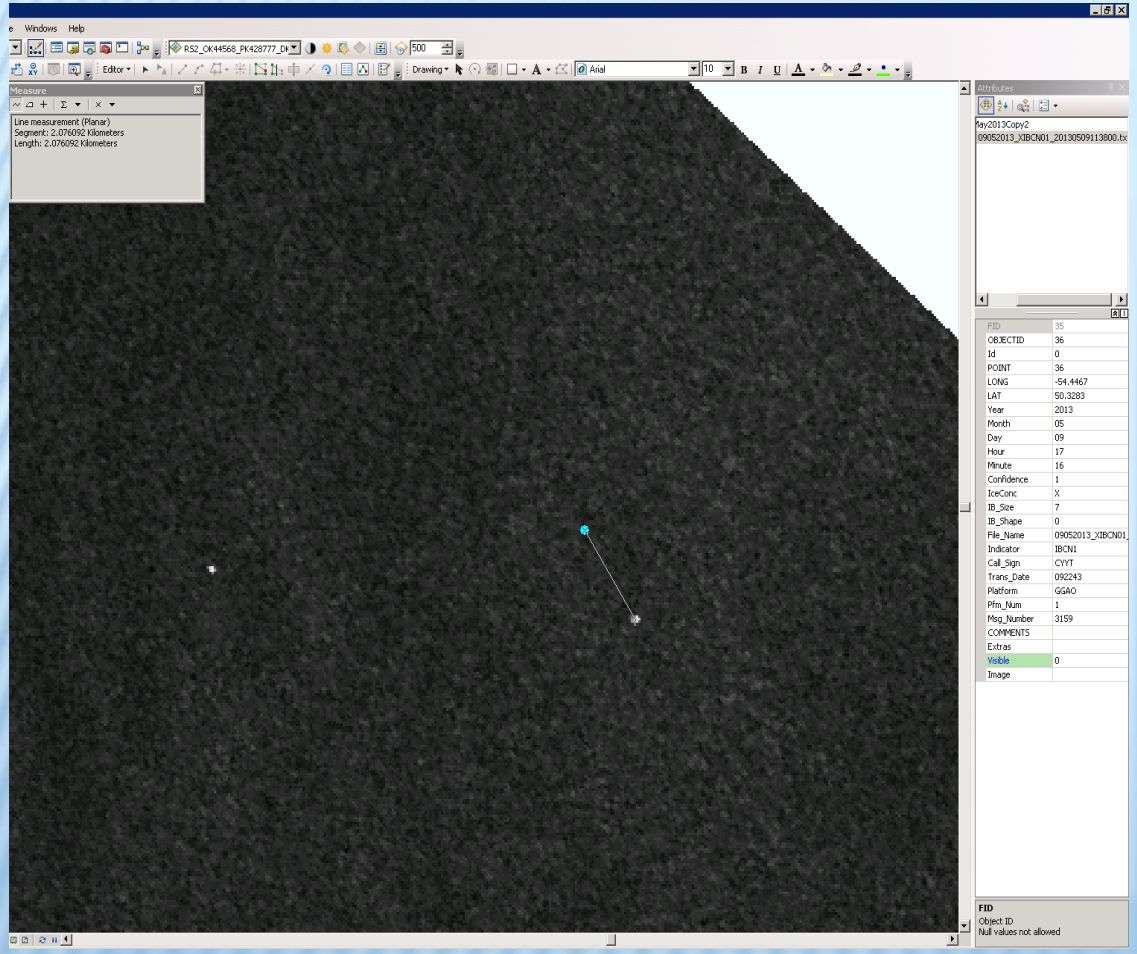
May 2015-Present: Research Assistant, University of Ottawa/Canadian Ice Service

- *Expanding the CIS dataset of validated icebergs*
- *Running various algorithms to validate icebergs and create an iceberg climatology of the Radarsat imagery archive*

September 2015: I will be formally starting my MSc at the University of Ottawa under the supervision of Dr. Luke Copland

- *Aim to determine the source of icebergs in Canadian waters with the hope of improving predictability and identify safer shipping routes/offshore oil platform locations*

IMAGE OR ILLUSTRATION



Example of matching an iceberg observation to a target on a Radarsat-2 SCW image

	Images Analyzed	Icebergs Validated	Icebergs Unable to be Validated	Total
2009	24	55	279	334
2011	15	260	456	716
2012	93	143	1315	1458
2013	53	222	970	1192
Total	185	680	3020	3700

Number of icebergs validated/discounted using Radarsat-2 Imagery and near-simultaneous IIP/PAL observations (all SCW)

MOST PRESSING GAPS/CHALLENGES

- *Detection of icebergs in SCW imagery*
  - *Iceberg detection algorithms*
- *The sources of icebergs in Canadian Waters*
  - *How/where they appear on ice charts produced by CIS*
- *Identifying iceberg drift patterns*
  - *Through Arctic/Eastern shipping routes and offshore oil platform areas*

WHO I AM

Ron Saper, research council officer within the Ice Mechanics group at the National Research Council, Ocean Coastal and River Engineering in Ottawa.

Engineer by training with specialities in image and signal processing, quantitative techniques, physical modelling.

Formerly owner of Vantage Point International Inc, an Ottawa-based technical services company that specialized in applications for RADARSAT-1/2.

Spent many years consulting for the Canadian Space Agency and Canadian Ice Service on marine applications for radar satellites.

I am a researcher and service provider within NRC.

INTERESTS

- Imaging radar for remote sensing of icebergs, ice islands, and other marine hazards
- Backscatter modeling for icebergs and ice islands in order to accurately discriminate them from other features or vessels
- Drift and deterioration research and prediction techniques
- Applying oceanographic techniques in ice forecasting, climatology and engineering especially for short term drift
- Demystifying the behaviour of icebergs and ice islands so that they can be better managed

MOST PRESSING GAPS

- Lack of understanding of radar backscatter mechanisms for glacial ice types
- No/limited operational ability to objectively predict short term looping trajectories of icebergs and rotation and drift of ice islands
- Absence of comprehensive and systematic information on local glacial ice hazard encounter risk across the North
- Lack of integration of remotely sensed glacial ice information into operational drift and deterioration models

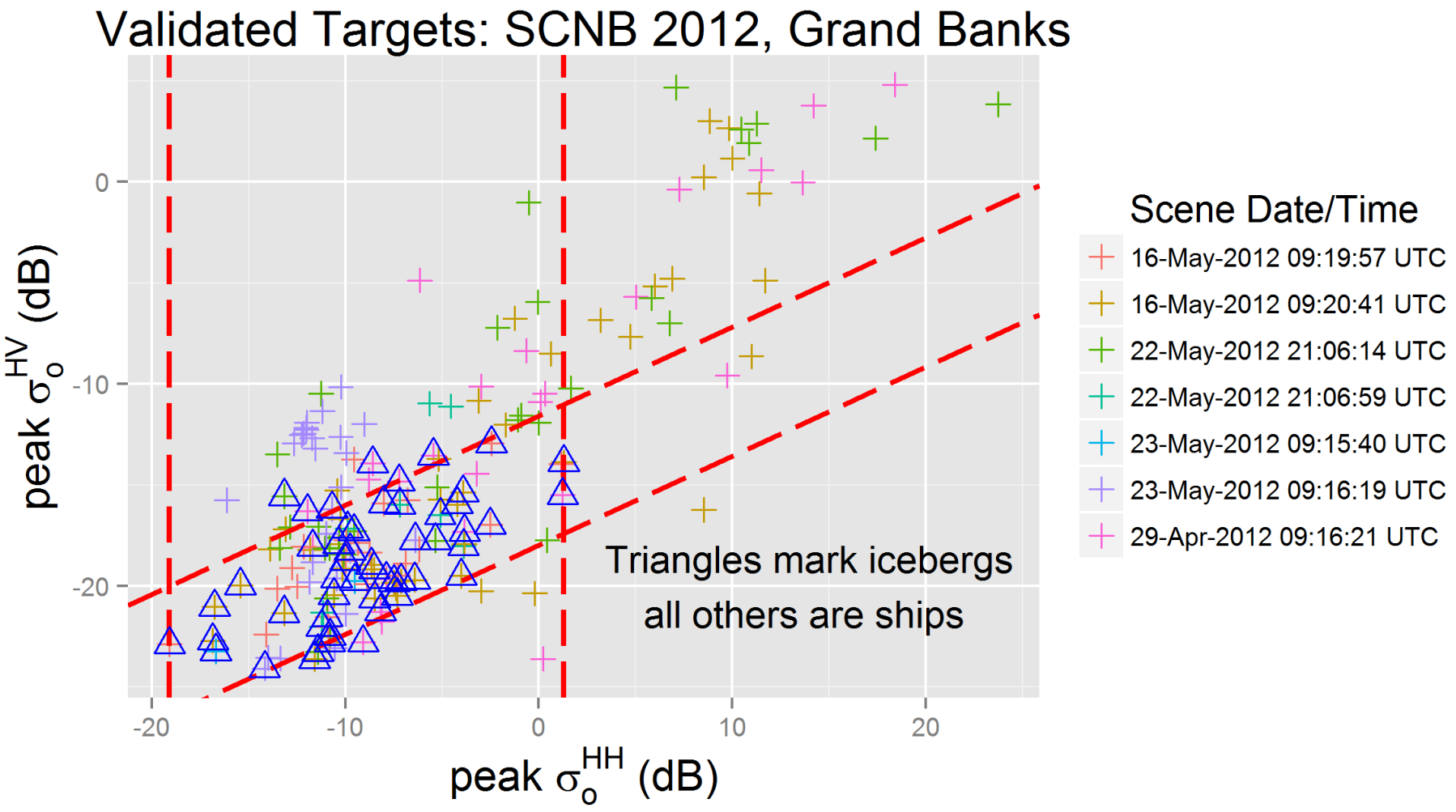
WHAT I AM OFFERING

- Knowledge of backscatter signatures for icebergs and ice islands
- Expertise in acquiring all weather imagery and detecting icebergs where ocean clutter conditions permit
- Methodology for using iceberg drift trajectories from the recent past to predict looping motions
- Experience with historical ice motion data sets
- Expertise in accessing RADARSAT-1/2 and Sentinel-1 data (subject to terms of use etc)

WHAT I AM LACKING/ CHALLENGES

- In situ validation of models and signatures
- Industry feedback on need for new approaches to drift modelling
- Industry feedback on needs for iceberg and ice island regional scale mapping from space
- Collaborative arrangements with other compatible partner organizations and individuals

BERGS VS SHIPS FROM SPACE



REFERENCES

Garret, Christopher*, Statistical Prediction of Iceberg Trajectories,* Cold Regions Science and Technology, vol 11, pp 255-266, 1985a.

Garrett, C., Middleton, J., Majess, F., and Hazen, M., *Analysis and prediction of iceberg trajectories*. Report to DS and S, Canada. 86 pp. 1985b.

Saper, Ronald, Arkett, Matt, Cheng, Angela , *A Technique for Discriminating Icebergs from Ships in RADARSAT-2 Imagery,* ASAR 2015 Conference (pending conference)

Smith, Stuart D., and Donaldson, Norman R.*, Dynamic Modelling of Iceberg Drift Using Current Profiles*, Canadian Technical Report of Hydrography and Ocean Sciences No. 91, Bedford Institute of Oceanography, September 1987.

WHO I AM

Paul Pestieau, M.Sc. Earth Physics

Ice modeling , Applied Science, Canadian Ice Service, MSC, EC

Science Manager

Enabling Ice forecasting Operations at CIS

INTERESTS

Ice modeling verification

Operational implementation of numerical models

Transferring Research to Operations

MOST PRESSING GAPS

Lack of data in the Arctic especially when it comes to ice thickness and pressure

Lack of clarity on the role of the CIS

Still large gap between ice modeling capacity and operational expectations

WHAT I AM OFFERING

Project Management of research to operations technological transfer

Verification expertise

Knowledge of infrastructure and people at Canadian Meteorological Centre

WHAT I AM LACKING/ CHALLENGES

(Same as on slide 3)

Lack of data in the Arctic especially when it comes to ice thickness and pressure

Lack of clarity on the role of the CIS

Still large gap between ice modeling capacity and operational expectations

WHY THIS IS IMPORTANT TO CANADIANS:

REFERENCES

Sea ice forecast verification in the Canadian Global Ice Ocean Prediction System

http://onlinelibrary.wiley.com/doi/10.1002/qj.2555/abstract

Who I am

- Name: Judith Bobbitt
- Affiliation: Oceans Ltd.
- Background: 36 years of conducting oceanography field programs and providing physical oceanography information for the oil industry
- Core Skills: Physical Oceanography, ice physics, meteorology
- Category: Research and Service Provider

Interests

- Measuring the dimensions of icebergs to obtain their draft, size, and mass for input into ice drift models
- Knowing the size and frequency of large icebergs for establishing engineering design criteria
- Ocean current modelling

Most Pressing Gaps

- Not having the input parameters for the dynamical iceberg drift model (draft, shape, mass, etc)
- Need new formulas for estimating iceberg size for ice management programs
- Need better ocean current models.

What I am offering

- 3-D iceberg measurements (we have developed a new sonar for the underwater portion and we have 3-D image software)
- Accurate marine weather forecasting
- Knowledge from 36 years of measuring and analyzing currents offshore Canada’s east coast
- Ocean current model in development to provide input to the iceberg drift model
- Long range forecasting of sea ice based on upper atmosphere dynamics
- Access to real-time current data being collected on the Grand Banks

What I am lacking/challenges

- Logistic support to measure icebergs and funds to cover labour costs
- Funds to complete the ocean current model

Profile Generation

- Combine all sonar and surface images
- Generate
  - 3-D view
  - Iceberg Properties (Draft, Length, Width, mass, etc.)
  - Stability Analysis