

SAMCoT News Letter 01/2015 (Jan.-June 2015)

Work Package Adm.: Administrative reporting

Briefing on Activities:

After an extensive reviewing exercise of the SAMCoT SFI through the midway evaluation from the Research Council of Norway the Centre received a very positive feedback, here some of the conclusions:

- *The Centre showed an excellent and relevant internationally recognized research environment. The Centre has excellent support from the host institution and its partners.*
- *The overall management is good and the different bodies, Board, EIAC, CMG and SAC have clear missions and roles in relation to each other.*
- *The Centre also demonstrates the capability to change direction when needed for example the interventions in WP1 and WP6. It was gratifying to see the good cohesion of all research environments despite the number and geographical dispersion of the partners.*
- *The panel also observed good financial gearing, that included a combination of in kind and cash contribution from a well-managed partnership with international industrial partners.*
- *Discussions with the student and post-doc community confirmed their enthusiasm for working on the challenging problems of ice and the Arctic environment. The group was extremely supportive and confident, that their work was delivering real value with good consequences for their employability.*
- *Both the evaluators and the Centre recognize the breadth of activity and the need to retain focus to deliver to the scientific and industrial users of its output*

The Research Council of Norway will make a report available with the conclusions and final recommendations after the summer.

Achievements:

- Midway Evaluation - Research Council of Norway
- SAMCoT Annual Report 2014: www.ntnu.edu/samcot
- SAMCoT HSE workshop, Svalbard March 2015
- SAMCoT Scientific PhDs/Postdocs Seminar May 2015
- SAMCoT 1st Board and EIAC Meeting May 2015
- Wenjun Lu wins the Chorafas Foundation Award
- NTNU hosted **POAC'15** with the sponsorship of Eni Norge, DNV GL, Kværner, Multiconsult, SAMCoT & Statoil
- SAMCoT First SAC and Second EIAC meeting, June 2015

On the communication from the Center published SAMCoT's Annual Report 2014 in March. Our members could also read about the centre activities is different mass media: i.e. 'Working safely to protect a cold, remote place' at Gemini.no, 'Taper vi kampen om Arktis?' at Teknisk Ukeblad, 'Safety on ice' at SAMCoT Webpage; and at the blogs on the SAMCoT e-room.

Different meetings and workshops took also place from January to June 2015: SAMCoT HSE Workshop hosted by UNIS in Longyearbyen; SAMCoT PhD, Scientific Seminar hosted by NTNU in Trondheim as well as other administrative meetings: The annual Site Visit with the Reseach Council of Norway, SAMCoT Board, SAC 1st meetings and EIAC 1st and 2nd meetings of 2015.

The Scientific Advisory Committee met in Trondheim on the 18th of June after attending the POAC'15 conference. Their meeting and the work presented by SAMCoT researcher at the conference helped the committee editing their annual report, now published at the SAMCoT e-room: R_R-PgR-1_SAC_2015. Professor Erland Schulson (SAC chairperson) summarized the content of the SAC report by saying: "I speak for all members of the committee when I say: 'well done and keep up the good work'".

Also the Exploitation and Innovation Advisory Committee is progressing on its effort to defining and presenting to all SAMCoT Partners an Innovation Template that will be used in the near future by the Partners to pinpoint SAMCoT's most valuables Innovation results. EIAC's activity in 2015 has increased as the scientific results from the Centre are utilized and taken further by its partners in an effort to achieve concrete innovative results.

On June 10th the researchers linked to the IVOS Associated project and representatives from Shell, DNV GL, Multiconsult, Total and GDF Suez participated in the project`s kick off meeting hosted at HSVA. During this meeting, HSVA's researchers presented previous test campaigns on ice-induced vibrations at model scale. In addition, the participants discussed the first IVOS physical model test series that will take place in August 2015. Currently HSVA's researchers are working on the design and production of an improved physical model. The structure will be equipped with Tactile sensors and Versatek Handles, allowing for measurement of local pressures during ice-induced vibrations with a sampling rate of 700 Hz. Tests in 4 ice sheets are scheduled for early September.

Notifications:

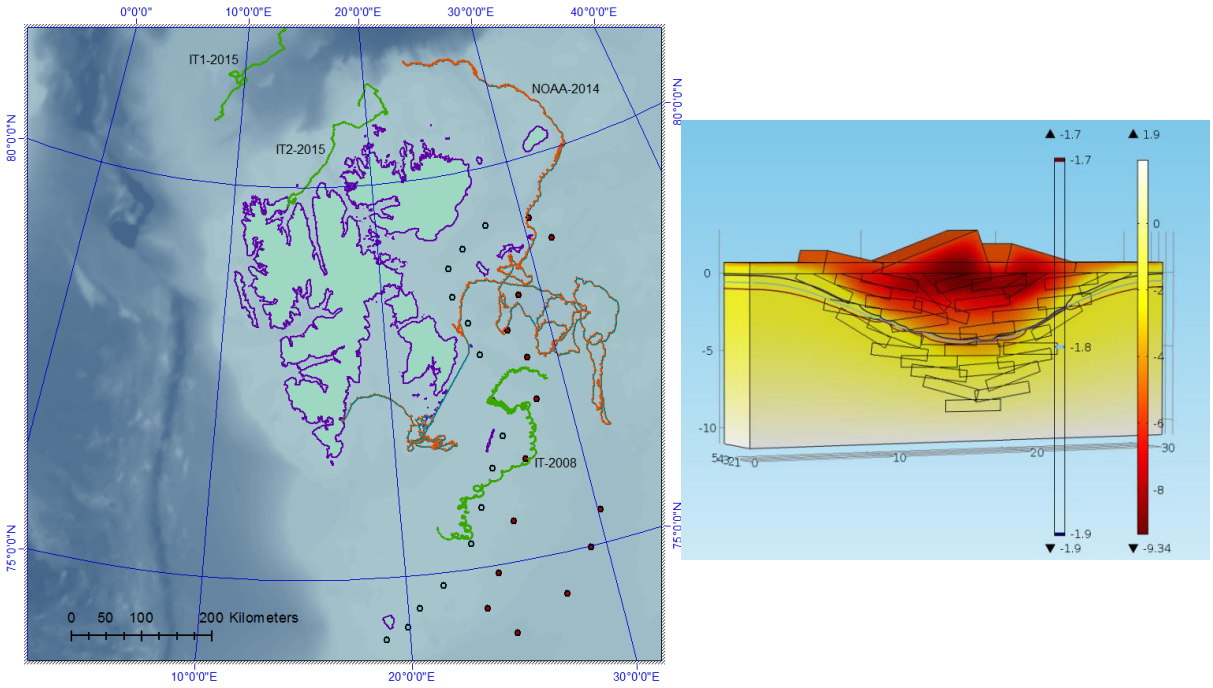
- *SAMCoT 3rd & 4th EIAC Meeting 2015:* September 9th (10-15 hrs, NTNU, Trondheim) & October 22nd (16-19 hrs, NTNU, Trondheim)
- *SAMCoT Technical Workshop 2015:* October 22nd & 23rd Trondheim, NTNU.
- *SAMCoT General Assembly 2015:* October 23rd Trondheim, NTNU
- *SAMCoT 2nd Board Meeting 2015:* November 12th Trondheim, Rotvoll Statoil Forskningssenter.

POAC'15: 194 Participants; 136 Reviewed Conference Papers & Key Notes. SAMCoT presented 46 CP!

Work Package 1: Data Collection and Process Modelling

Briefing on Activities:
In period from January to May 2015 theoretical investigations, laboratory and field works were performed within planned activities of WP1.

Theoretical investigations were focused on the analysis of characteristics of surface currents and drift ice and numerical modelling of thermodynamic consolidation of drift ice ridges in the north-west Barents Sea. Data of ice trackers Oceanetic Measurements and NOAA surface drifters deployed in 2008-2015 were used for the analysis.
Based on these data available trajectories of ice drift from the north-west Barents Sea to the region of Bear Island were constructed. Water and air temperature along the trajectories in February-May were reconstructed from NCEP/NCAR archive. These data were used in formulation of the boundary conditions in finite element model of thermodynamic consolidation of drift ice ridge (Marchenko, 2008). 3D simulations performed in Comsol Multiphysics 5.0 demonstrated synchronous consolidation of ice rubble filling ridge keels and melting of the ridge keels from below.



(a) (b)

Figure 1. Trajectories of ice trackers deployed by AT UNIS (green lines), trajectory of NOAA surface drifter (orange line), two drift trajectories of model ice ridges (blue and red dots) (a). Consolidated and melted ice ridge after 2 months drift (b).

Laboratory works included set of original experiments on the investigation of thermo-elastic waves in saline ice. Cylindrical Ice samples were insulated by foam plastic from lateral sides and from the bottom. Their surface was under periodical cooling with 12 minutes period produced by cooling system at cold laboratory of UNIS. During the 12 minutes period the room temperature is varied with amplitude of about 1 C. FBG strain sensor registered vertical displacements of the ice surface with the same period and amplitude of about 1 ?m. The dependence of the amplitude from ice salinity and temperature were investigated during the experiments.

Elaborated theory based on modified Darcy's law describing liquid brine migration through the ice is used to explain the dependence of the amplitude of the thermos-elastic waves from the ice temperature and salinity.

Field works were focused on in-situ tests of ice strength, morphological studies of icebergs, standard oceanographic measurements in ice covered waters (CTD profiling, ADCP profiling of water velocity profile, ADV measurements of water velocity in ice adjacent layer), monitoring of wave damping in marginal zone of drift ice, deployment of ice trackers on drift ice ridge, and monitoring of ice load on fixed quay. In-situ tests for compressive, tensile and shear strength of floating sea ice were performed with original rig creating horizontal load over entire ice thickness. Tests for flexural strength and torsion strength were performed with original rig creating vertical load in upward and downward directions. Tests results will be used for the formulation of failure envelope of floating ice for in-plane and bending deformations.

(a) (b)

Figure 2. Tests for tensile (a) and compressive (b) strengths.

Oceanographic measurements were performed in the Van Mijen Fjord (west of Spitsbergen) on shallow water covered by ice, and near the front of Paulabreen glacier, and in the Wahlenberg Fjord (west of North-East Land) below level ice and around floating iceberg frozen in fast ice.

Morphological studies of 2 icebergs in the Wahlenberg Fjord were performed with laser scanner Riegl Vz-1000. Shapes of icebergs sails and icebergs masses were reconstructed using collected data. Monitoring of surface waves in marginal zone of Arctic drift ice was performed to the north of Spitsbergen. During the experiment RV BjorkHoug penetrated through MIZ on 2 nm. Wave measurements were performed on several stations by 2 sensors SBE 30plus mounted on the same rope fixed on the ship board. In the same place ice trackers equipped with thermistor string was deployed on drift ice ridge with 8 m draft.

Monitoring of ice loads on the cofferdam of fixed quay in Kapp Amsterdam and shore line in Svea Bay with load cells Geokon was performed synchronously with water level and ice temperature measurements. Both ice loads on cofferdam and ice loads on shoreline show clear dependence from the phase of semidiurnal tide, but character of this dependence varies with the time. Highest loads are observed during spring tides, and lowest during neap tides. Formation of ice loads on the shoreline is explained by variable shape of the ice cross the fjord over the tidal cycle. Ice loads on the cofferdam of the fixed quay are created by the ice confined inside the cofferdam. The origin of these loads is related to upward and downward migration of liquid brine through the ice under the influence of tide induced water pressure below the ice and brine freezing in top layers of the ice. This process is accompanied by the increase of the ice temperature.

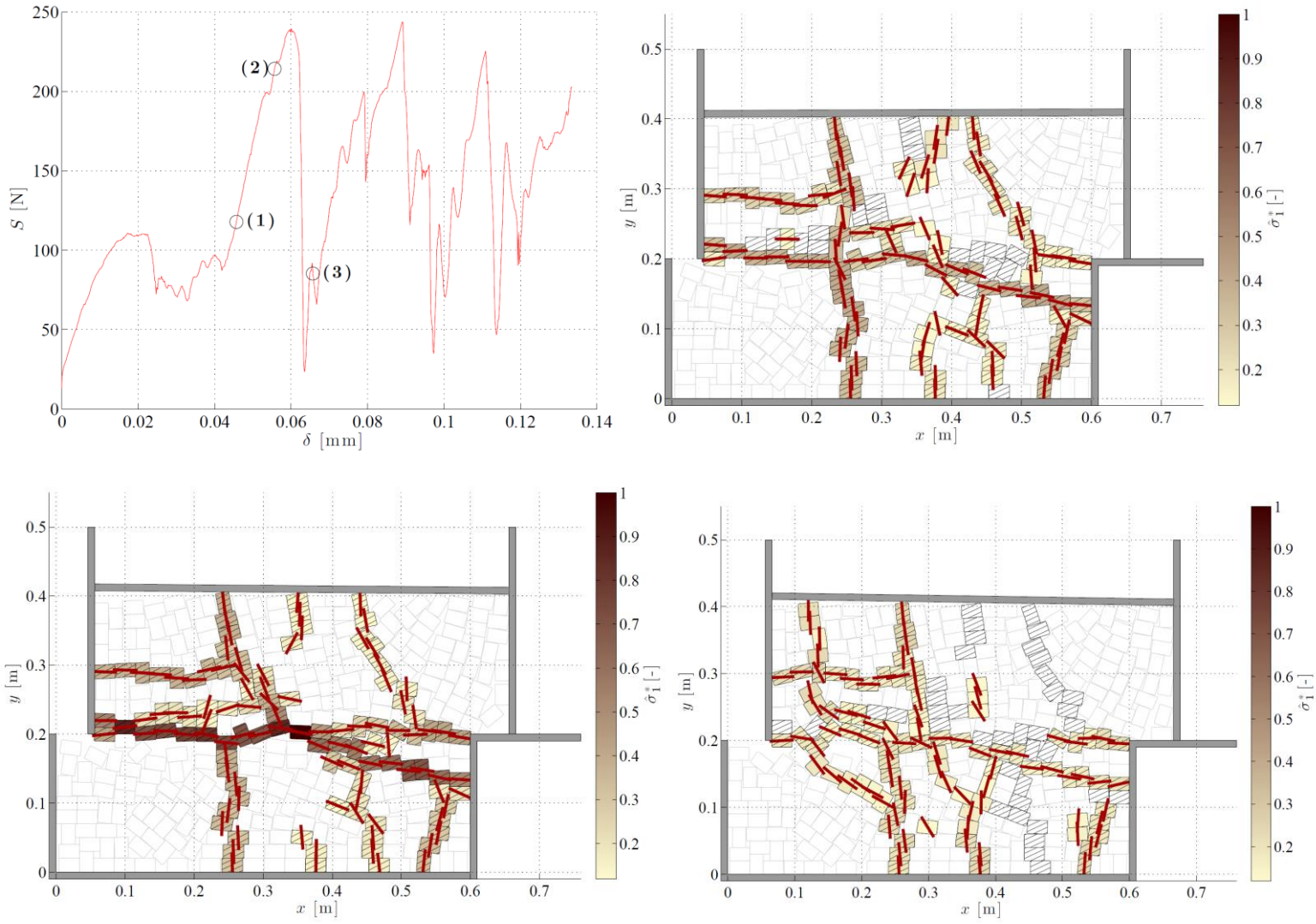
Paper on data processing and modeling of surface wave propagation below the drift ice in the north-west Barents Sea was published in Geophysical Research Letters (42,6,1863-1870). Based on WP1 activity 12 papers have been submitted for POAC 2015.

Work Package 2: Material Modelling

Briefing on Activities:

Arttu Polojärvi works currently with the modelling of freeze bonds in 3D DEM simulations and the results seem fairly promising. Together with Janne Ranta he has proceeded with his work on statistics of ice loads.
The work on homogenization of ice rubble with Sergey Kulyathkin is ongoing with Artu visiting NTNU regularly. Sergey also visited Aalto in June as part of this ongoing collaboration. In addition to this work, Arttu has supervised a master's thesis on 2D DEM simulations on ice loads on structure in shallow water.

- Journal paper done with Anna Pustogvar and Jukka Tuhkuri was finished and published: 'Polojärvi, A., Tuhkuri, J., Pustogvar, A. (2015). DEM simulations of direct shear box experiments of ice rubble: Force chains and peak loads. Cold Regions Science and Technology, 116, pp. 12-23.'
- Have been participating in writing of three conference papers for POAC and three for the XI Finnish Mechanics Days.

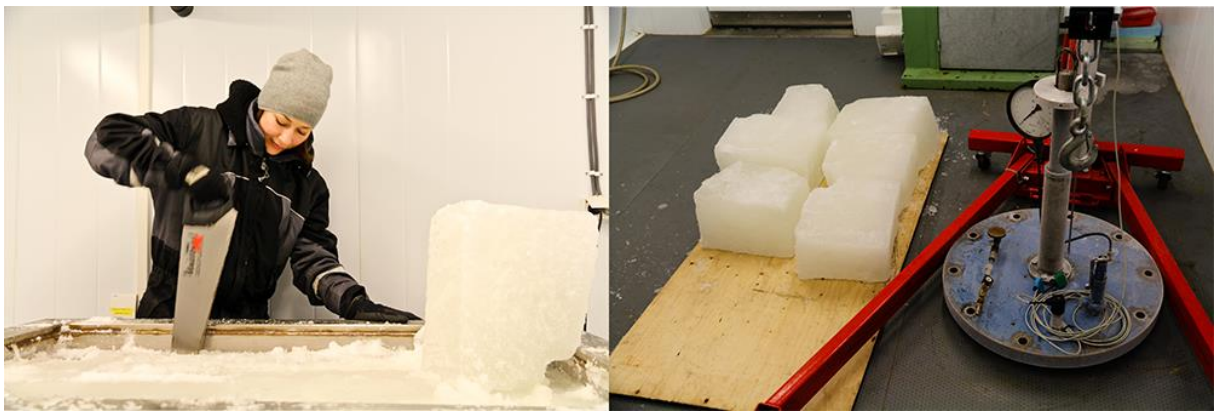


2D discrete element method simulations of laboratory scale punch through tests.

Sergey Kulyakhtin submitted in 2015 one journal paper to Cold Region Science and Technology devoted to the prediction of ice rubble shear strength using critical state theories.

Two more papers are in progress. One is comparing the results of ice rubble - structure interaction tests performed during RITAS project with the numerical predictions from implemented material model based on breakage mechanics concept. Another one is dealing with the definition of equivalent continuum medium from discrete element simulations with particular focus on the symmetry of equivalent stress tensor and importance of couple stress tensor.

PhD candidate Anna Pustogvar is working on two topics. Both of them try to reach a better understanding of the porosity of the material, the ice itself and macroporosity of ice rubble. During the period between January and June Anna Pustogvar submitted a conference paper to POAC'15. The paper reveals superiority of hydrostatic weighing in paraffin over standard mass/volume method for measuring ice density both in the field and in the laboratory.



On her experimental work Anna uses factorial design of experiments which so far has been overlooked in the ice research. Nevertheless it has a great potential both in the field and in the laboratory testing. Moreover, Anna successfully carried out laboratory tests on ice rubble volumetric porosity in March/April. The tests were performed for determining input parameters and validation of an analytical model predicting ice rubble porosity using size distribution of ice blocks as a principle parameter and few secondary parameters. Submission of a Journal paper on volumetric porosity of ice rubble is planned for autumn 2015.

Yared Bekele has achieved good progress regarding the numerical implementation of a THM coupled finite element code, performing a preliminary verification by simulating one-dimensional ground freezing. He presented his research progress and results at the SAMCoT PhD & Scientific Seminar held in Trondheim from May 6-7, 2015. In addition Yared has participated in the VI International Conference on Coupled Problems in Science and Engineering held in Venice from May 18-20, 2015 and the III International Conference on Isogeometric Analysis held in Trondheim from June 1-3, 2015. One journal paper is currently under revision and another paper is under preparation.

WP2 has also produced a Master thesis on FEM analysis of full-scale and model-scale ice rubble punch tests.

Work Package 3: Fixed Structures in Ice

Briefing on Activities:

Torodd Nord recently published a journal paper (JP) in Cold Region Science and Technology (CRST) and sent a revised second JP back to CRST. This paper dealt with how the structural vibrations affect the ice pressures. He will submit a third paper soon to the Journal of Computers and Structures concerning the force identification on the Nordströmsgrund lighthouse. Torodd presented preliminary results at the SAMCoT scientific seminar in May, and Eliz-Mari Lourens presented it in St. Petersburg at the International conference on Advanced Problems in Mechanics (APM-2015). Torodd presented a paper on POAC`15: "*sensor network for dynamic ice-force identification: The Hanko-1 channel marker case study".*

Hayo Hendriksen is about to complete his thesis and plan to submit this autumn. He has submitted revised versions of two journal papers and the third is under internal review. The three papers deal with a) Numerical modelling of IIV considering the contact are between ice and structure, b) A detailed analysis of the forced vibration experiments from 2011 and c) Scaling and dimensionless parameters. These three papers will make up the core of his PhD.

During the Spring 2015 Janne Ranta wrapped up two conference papers, one for POAC 2015 and the other for XII Finnish Mechanics Days. Both conferences took place in June 2015. The title of the POAC paper was "Ice load estimation through combined finite-discrete element simulations" and the title of the Finnish mechanics days paper was "A review on a peak ice load data from 2D combined finite-discrete element method simulations". Janne will continue his work by preparing two journal manuscripts based on topics discussed in previously published conference papers.

Åse Ervik produced and presented one Conference Paper for POAC`15. Åse participated on the N-ICE project, working on ice ridge properties in collaboration with SAMCoT's WP1 and Norwegian Polar Institute in Arctic basin.

Lance frozen in the background, picture taken by Åse from the location of once of the Ridges that she studied.

Sometimes being at the right place it's all it takes to find out about an exciting research opportunity, that was the case for Åse Ervik, SAMCoT PhD within work package 3. While attending a HSE course in October 2014 she discovered that the N-ICE project was looking for researchers to join the expedition.

The Norwegian young sea ice cruise N-ICE had as main objective to understand the effects of the new thin, first year, sea ice regime in the Arctic on energy flux, ice dynamics and the ice associated ecosystem, and local and global climate.

A prototype from a different research group at the expedition crushed into one of Åse's ridges.

Åse focused on Ice Ridges and during the three weeks that she worked on the ice, from mid May to mid-June, she was able to `follow` two different ridges.

`Two weeks is a long time series for this type of field work and the ridges were changing fast. Data on ice ridge profiles from manual drilling compared to sonar profiling, temperature and salinity data and uniaxial compression data can be used to study the thermal processes as a first year ice ridge melts as well as how the mechanical properties changes. Two thermistor buoys have also been deployed in two separate ridges and will drift together with the ridges until they melt, hopefully surviving summer` explains Åse.

In addition to Åse, another SAMCoT researcher joined the N-ICE project, Aleksey Shestov was there to study the process of transforming from a first year to a second year ice ridge as part of his Post-doc at UNIS.

Work Package 4: Floating Structures in Ice

Briefing on Activities:

At the end of 2014, immediately after the defence, Wenjun Lu in WP4 together with his supervisors Sveinung Løset and Raed Lubbad initiated the test campaign of 'sea ice's fracture toughness test'. In early 2015, a trial test was conducted in SVEA. The test has been theoretically designed (reported in a conference paper) and the equipment were tested out in the field. The DitchWitch trencher was proved to be an effective tool in cutting large ice sheet. Based on the experiences obtained in this trial test, a new test campaign is scheduled in March 2016.




PhD candidate Chris Keijdener was working on improving the beam model used in his model so that it correctly takes into account geometrically-nonlinear effects. This allows the influence of buckling on the interaction between vessel and level ice to be studied.
In addition, work on the hydrodynamics was started. Analytical solutions to the simplified interaction problem were solved. The goal for the summer will be to formulate a discrete model of the hydrodynamics which can accurately reproduce the analytical results. This discrete model will serve as an upgrade for any existing two-dimensional interaction model when considering level ice, by allowing them to include hydrodynamics effects.
PhD candidate Marnix van den Berg has been working on a model for the consolidated layer of ice ridges. A random lattice model is developed based on Voronoi tessellation. The main advantage of such a model is that fracture or failure can be included in a logical manner. M. van den Berg also finalized two POAC papers; one on the application of non-smooth discrete element modelling of ice rubble, and one on a concept design for a meso-scale floater.

The coming period, M. van den Berg will focus on the modelling of failure, and on the interface between the non-smooth rubble model and the random lattice model for the consolidated layer.

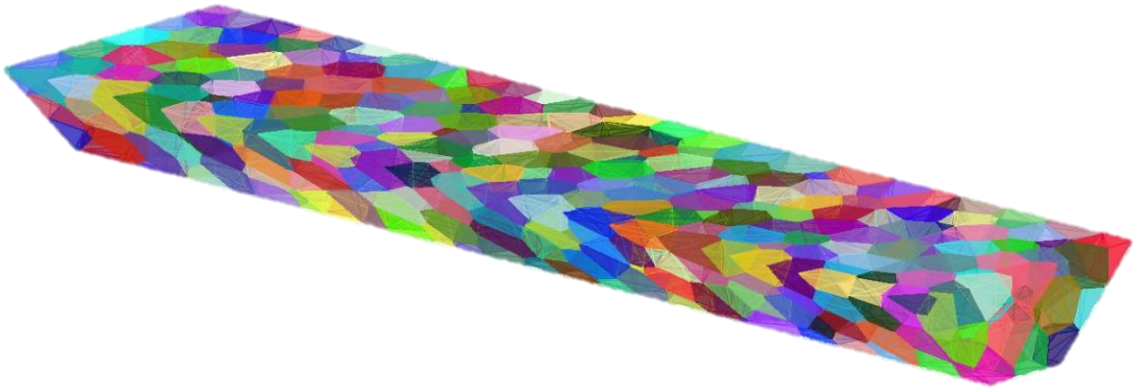


Figure 1: A graphical illustration of the random lattice model based on Voronoi tesselation

Martin Storheim has focused mostly on fracture modelling in the first part of 2015, combined with writing of the PhD thesis. A large benchmark study was performed, in which many popular fracture criteria were tested and their robustness documented, i.e., their uncertainty in fracture prediction. During the period, two journal papers were submitted and a third was approved. Additionally, the thesis work is on schedule for submission during the autumn 2015.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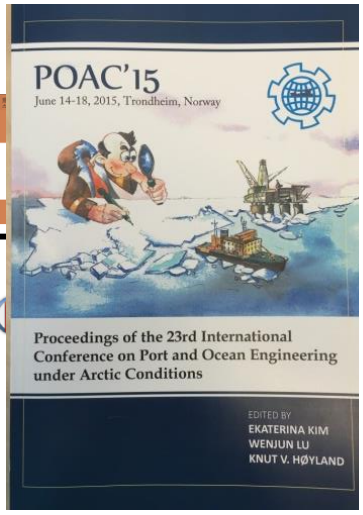
A damage-based failure model for coarsely meshed shell structures

Martin Storheim [a, b, c, *], Hagbart S. Alsos [d], Odd Sture Hopperstad [e], Jørgen Amdahl [a, b, c]

[a] Norwegian University of Science and Technology, Institute of Marine Technology, NO-7491 Trondheim, Norway
[b] Centre for Sustainable Arctic Marine and Coastal Technology (SAMCoT), Norway
[c] Centre for Autonomous Marine Operations and Systems (AMOS), Norway
[d] Reinertsen AS, Trondheim, Norway
[e] Structural Impact Laboratory (SIMLab), Center for Research-based Innovation, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway



Ekaterina Kim together with Profs.: Jørgen Amdahl, Knut Høyland, Raed Lubbad, Sveinung Løset, Erland Schulson, Post Doc Wenjun Lu and PhDs Martin Storheim and Ming Song continue to participate in five inspirational activities:
(1) – Understanding ice-structure interaction processes;
(2) – Search for scale and size invariant ice parameters that can be used for validation of numerical and analytical models of ice-structure interactions;
(3) – Gain expertise and knowledge in non-linear finite element analysis of ice-structure collisions in shared-energy regime;
(4) – Within the context of local shell plating design, a deeper understanding of the theoretical considerations that underlie rule-based formulations is required for designing safe and efficient structures and is essential for design; and
(5) – In order to support the development of numerical ice basins, a theoretical framework of Wenjun Lu for calculating ice loads due icebreaking processes has been extended to include localized edge crushing.

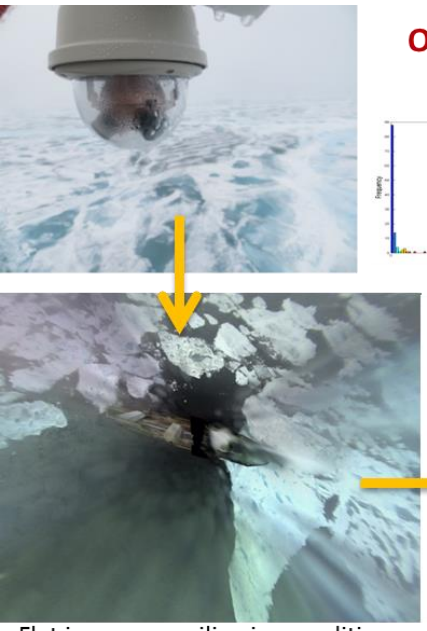
Last but not least – POAC'15. During the period, one journal paper published, two – were submitted. Some findings will be presented at POAC'15 and during the Interdisciplinary PhD and Post Doc School on Svalbard in August.

Work Package 5: Ice Management and Design Philosophy

Briefing on Activities:

Professor Roger Skjetne has been heading WP5 since 1st January 2015. Øivind Kjerstad (researcher at NTNU/UNIS) is deputy leader of the work package.
The primary goal of WP5 is to establish a philosophy that ensures that the Ultimate Limit State (ULS) and Accidental Limit State (ALS) requirements are fulfilled by Arctic offshore structures without being overly conservative. The philosophy needed by the industry shall consider use of ice management means such as icebreakers, iceberg towing vessels, structure disconnection and reconnection capabilities, and a sophisticated ice surveillance system for online situational awareness of the ice management process. The efficiency of ice surveillance (detection, tracking and forecasting) shall be quantified.

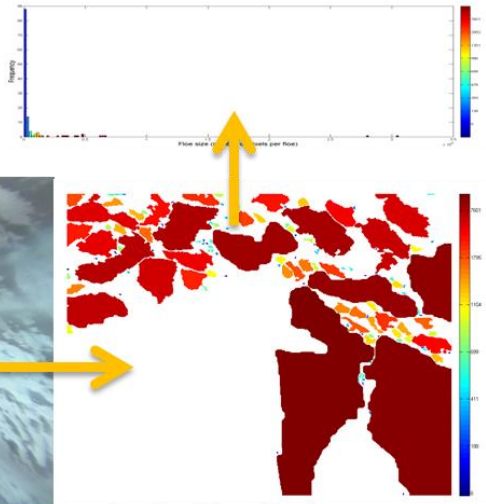
On the following slides an example of the work done by WP5 related to technologies and methods for sea-ice surveillance.



Flat image prevailing ice condition

OATRC'13: 360CamSys

Ice floe size distribution

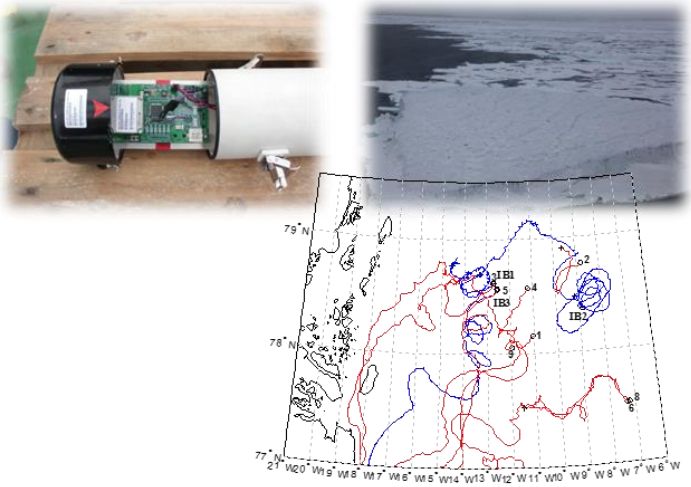


Ice floe identification

Renat Yulmetov

Ice Tracking Drifters

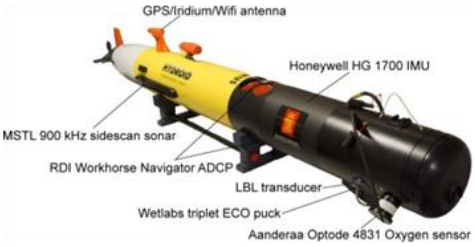
- Best student paper award at IAHR 2014.



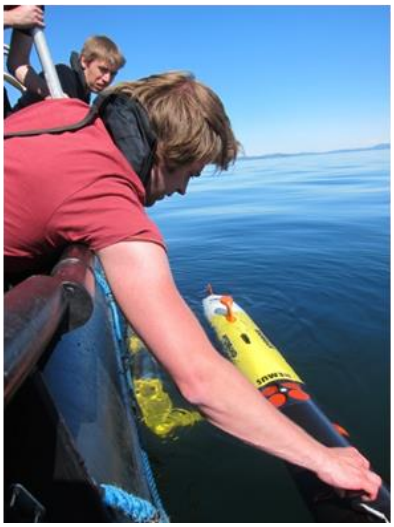
Launch and recovery in nice conditions.

Petter Norgren

AUV Under Ice research



The NTNU AUV – REMUS 100

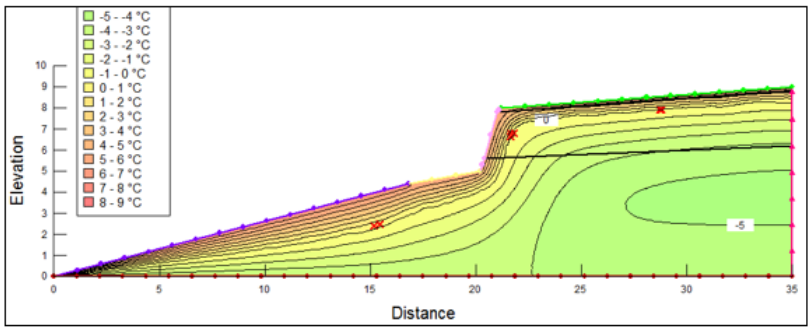


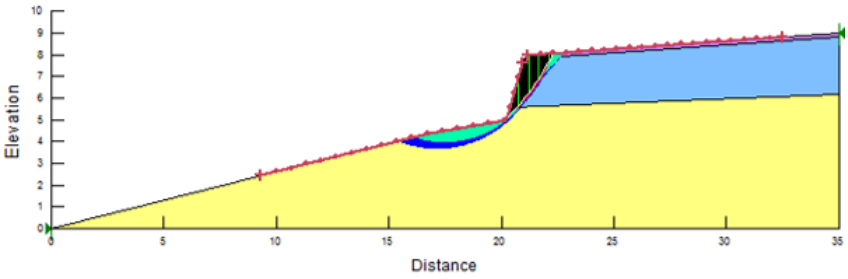
Launch and recovery in the Arctic polar night in January 2015.

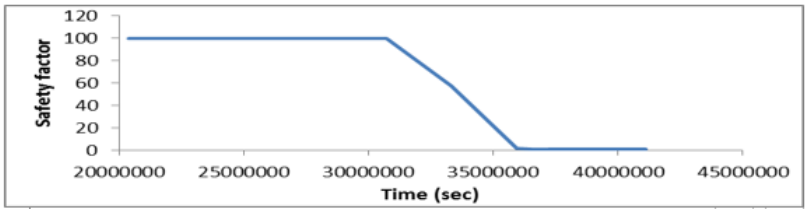
Work Package 6: Coastal Technology

Briefing on Activities:

Researchers in WP6 continue to analyse full-scale data from different sites in the Arctic trying to understand the mechanisms behind Arctic coastal erosion. A few numerical models are under development in WP6 in an attempt to predict the effects of climate changes and the presence of manmade structures on the erosion rates in the Arctic.







The scientific production of WP6 since January has been quite good. We published a number of papers in scientific journals and international conferences. PhD student Emilie Guegan has been working hard during the first half of 2015 to finalise her PhD study. She has written her thesis and submitted a number of manuscripts for publication in scientific journals. The public defence of Guegan's doctoral thesis is planned after the summer of 2015.

Postdoc Seyed Ali Ghoreishian Amiri and PhD student Mehdi Kadivar have joined WP6 in 2015 to strengthen the frozen soil research in WP6 and hence to bridge the gap with WP2. Amiri is working on a new concept to develop constitutive models for frozen soils. This effort is very useful for the development of the so-called practical THM models, which can be used to answer engineering questions. The PhD students and Postdocs of WP6 presented their latest findings during SAMCoT Scientific Seminar in May. Good discussions took place where the audience gave their feedback. In general, we received signs of satisfaction towards the progress in our work package. In May, SAMCoT leader Prof. Sveinung Løset and WP6 leader A/Prof. Raed Lubbad visited Moscow State University (MSU) to discuss and find ways to strengthen the collaboration with MSU in WP6. The discussions were fruitful and revealed mutual interests and we are now working together to mature this into concrete plans. We have also agreed the PhD student Daria Aleksyutina from MSU should stay at NTNU for 3 months during 2015.