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VARIOUS ICE PHYSICS AND MODELLING SAMPLES

Abstract: *Sea ice serves as both an indicator of change and as an amplifier of change. This loss of sea ice is perhaps one of the most visible large-scale changes on Earth's surface connected to planetary warming, with significant implications for the Arctic region and beyond. The response of Antarctic sea ice to climate change has been more complicated and less well understood. Advancing our ability to analyze, model, and predict the behavior of sea ice is critical to improving projections of climate change and the response of polar ecosystems, and in meeting the challenges of increased human activities in the Arctic. Over the past decade or so, research on modeling sea ice and its role in Earth's climate system has blossomed, with fundamental contributions from many areas of applied and computational mathematics. The aim of the paper is to present some ice modelling designs and their properties.*

Key words: Ice, Modelling, Properties, Physical, Mechanical.

Most of the modeling ideas and techniques in the following apply to sea ice around Arctic and Antarctic regions. However, there are certain topics that are traditionally more relevant to either the Arctic or the Antarctic. For example, melt ponds are generally not observed on Antarctic sea ice. Grainy polycrystalline microstructures, often associated with growth under more turbulent conditions or the formation of "snow-ice" on top of flooded sea ice, have typically been of more interest in studies of Antarctic sea ice. Likewise, studies involving wave-ice interactions and pancake ice, which forms in wavy conditions, have been more focused in the Southern Ocean. However with Arctic sea ice receding, wave activity has increased, along with similar types of studies in the Arctic. The paper is organized as follows. We begin with a

summary of experiments done by some researchers and scientists with their names, title of the research, factors or parameters included, properties considered, what type of experiment done, observations looked at, and the location of the experiment. And finally briefly explain the results of the various experiments.

Author	Title	Material Parameters	Properties	Exposure (lab/field)	Observation	Location
Bragov, L. Igumnov, A. Konstantinov, A. Lomunov, A. Filippov, Yu. Shmotin, R. Didenko, and A. Krundaeva(2015)	Investigation of strength properties of freshwater ice	strain rates ($10^{-4} - 3\cdot10^{3}$ s^{-1}) and temperatures of -5° C, -20° C, -40° C and -60° C	compression and at splitting and at shear	the Kolsky method was used with various embodiments of split Hopkinson bar	elasticity modulus of ice was defined (by the displacement of test machine grips), which amounted to about 200 MPa at a temperature of -5°C and ∼310 MPa at a temperature -60°C	Russia
Julia Brnson,Damian Lawler and John. Glen(1992)	The laboratory simulation of needle(columnar) ice	Moisture content and temperature	Ice growth	Soil moisture	Ice grow with smooth or intermittent profile.	United Kingdom
A. K. Naumann, D. Notz, L. Havik, and A. Sirevaag(2012)	Laboratory study of initial sea-ice growth: properties of grease ice and nilas	Wind, turbulent water and current	Ice growth	Both lab and field	NaCl solution of about 29 g kg−1	Germany and Norway
Jinlun Zhang (2020)	Sea Ice Properties in High-Resolution Sea Ice Models	horizontal resolutions	viscous-plastic sea ice rheology, a mechanical ice strength and an ice ridging	Driven by the same atmospheric forcing	Increasing model resolution from 6 to 2 km does not significantly improve model performance when compared to NASA Ice Bridge ice thickness observations	U.S.A.

J. Schwarz and W. F. Weeks. (2017)	Engineering Properties of Sea Ice	temperature, strain-rate, brine volume, and loading direction	mechanical, thermal, and electrical properties	Field and lab	Sea ice design of ice-breaking ships to Arctic drilling platforms and man-made ice islands.	United Kingdom
Christopher C. Schneck, Tadros R. Ghobrial , Mark R Loewen(2019)	Laboratory Study of the Properties of Frazil Ice Particles and Flocs in Water of Different Salinities.	frazil ice at salinities of 0 ‰, 15 ‰, 25 ‰, and 35 ‰	size and shape	experiments were conducted in a large tank in a cold room with bottom mounted propellers	The overall mean size of frazil ice flocs in freshwater was 2.57 mm compared to a mean size of 1.47 mm for flocs in saline water	Canada
Alexander T. Bekker, Sergey G. Gomolskiy, Olga A. Sabodash, Roman G. Kovalenko, Tatyana E. Uvarova, Egor E. Pomnikov(2010)	Physical and Mechanical Properties of Modeling Ice for Investigation of Abrasion Process on Ice Resistant Offshore Platforms	Loading rates, temperature and salinity	Structure, Density, Ice salinity and strength	Lab	The test results have shown that in all cases distribution of ice strength is well-described by the normal law	Russia

Summary of experiments

Results

Bragov, L. Igumnov, A. Konstantinov, A. Lomunov, A. Filippov, Yu. Shmotin, R. Didenko, and A. Krundaeva (2015)

The various conclusion were observed [1, p. 5]

Mechanical properties of ice both at compression and at splitting and at shear increases with increasing of strain rate, and at lower temperatures. Observable quite a large scatter of strength properties of ice under different loading conditions, apparently. Associated with the possible heterogeneity of the structure of the frozen samples.

Julia Brnson, Damian Lawler and John. Glen (1992)

The various conclusion were observed [2, p. 5]

Intermittent growth were produced in experiments that showed needle ice contained bands of sediment. They're thought to grow when there is a disturbance to the growth environment which affect the stability of the freezing front, as results of imbalance of heat or moisture flowing to and from freezing front. Clear needle ice is thought to form under external conditions and the periods of no growth are caused by too much heat flowing to the freezing front.

A. K. Naumann, D. Notz, L. Havik, and A. Sirevaag (2012)

The various conclusion were observed [3, p. 5]

In turbulent water, we find that the bulk salinity stayed almost constant as long as grease ice was present. Measuring the solid fraction of a grease-ice layer, we find that it was constant in the first hours of ice formation with an average value of $\varphi = 0.25$, which is in good agreement with geometrical considerations and the work of Martin and Kauffman (1981) and De la Rosa and Maus (2012).). In our study the ice thickness grew twice as fast in the experiments with current and wind as in the quiescent experiments or the experiments with waves because in the experiments with current and wind an open water area remained at the surface throughout much of the experiment.

Jinlun Zhang (2020

The various conclusion were observed [4, p. 6]

This suggests that the large-scale sea ice properties of the model are insensitive to varying high resolutions within the multifloe scale (2–10 km), and it may be

unnecessary to adjust model parameters constantly with increasingly high resolutions. This is also true with models within the aggregate scale (10–75 km), indicating that model parameters used at coarse resolution may be used at high or multiscale resolution.

Christopher C. Schneck, Tadros R. Ghobrial, Mark R Loewen (2019)

The various conclusion were observed [6, p. 6]

A total of 46 laboratory experiments were performed to determine the properties of individual frazil ice particles and flocs at salinities of 0 ‰, 15 ‰, 25 ‰, and 35 ‰. Visual examination of the images clearly showed that there were more irregular shaped particles in saline water than in freshwater. The average particle and floc growth rates decreased as salinity increased 5 and the freshwater growth rates were ~ 4 times larger than the average growth rate in saline water. The mean frazil ice particle sizes ranged between 0.52 and 0.45 mm with particles sizes in freshwater ~ 13 % larger than in saline water.

Alexander T. Bekker, Sergey G. Gomolskiy, Olga A. Sabodash, Roman G. Kovalenko, Tatyana E. Uvarova, Egor E. Pomnikov(2010)

The various conclusions were observed [7, p. 6]

- Ice density in the middle layer of the block is a little higher than in the top and bottom layers. The average ice density value at t =-20°C made 0.909 g/cm3 that match well the results of other researchers.
- salinity values of the upper and lower layers is a little more than range of salinity values of the middle layer, and its salinity is 3% more than salinity of the upper and lower layers. The same distribution of salinity in the layers was watched in all ice blocks irrespective of initial salinity of water and availability of circulation.
- The ice had a uniform structure with minor impurities.

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