Summary of the 27th IAHR International Symposium on Ice

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Abstract

The 27th IAHR International Symposium on Ice, held in Gdańsk, Poland, between 9 and 13 June 2024, gathered 153 scientists and industry professionals from 14 countries. Organized by Gdańsk University of Technology, the event focused on key global ice-related challenges, including ice mechanics, ice-structure interactions, climate change impacts on the cryosphere, and offshore wind development in the Baltic Sea. With 93 papers in the published conference proceedings, the symposium showcased diverse methodologies and multidisciplinary research on sea and river ice dynamics, as well as engineering challenges in cold regions. The event fostered engaging discussions and facilitated collaboration, reinforcing its role as a leading platform for advancing ice research. In this paper this event is summarized.

1. Short history of the Ice Symposium

The IAHR Symposium on Ice has a longstanding history, beginning in 1970 with its inaugural conference in Reykjavik. Since that time, this prestigious event has continued biennially, held in various global locations under the auspices of the International Association for Hydro-Environment Engineering and Research (IAHR). The honor of hosting the symposium is extended to the world's leading institutions in ice research, representing three continents: Europe, North America, and Asia. In recent years, the symposium has been hosted by:

- École de Technologie Supérieure, Montreal, in 2022,
- Norwegian University of Science and Technology (NTNU), Trondheim, in 2020,
- Far Eastern Federal University (FEFU), Vladivostok, in 2018,
- University of Michigan, Ann Arbor, in 2016.

This rotation highlights IAHR's commitment to promoting advancements in ice research through a diverse international exchange. By moving the conference across continents, the IAHR ensures a broader representation of global expertise, fostering regional participation and engagement. This approach encourages increased involvement from researchers and institutions within each region, as the event moves between Europe, Asia, and North America in rotation. The geographical diversity not only enhances the scope of scientific dialogue but also strengthens the local research communities by offering them the opportunity to contribute more actively to the international ice research field.

Observing climate changes in recent years has led to a twofold effect on the field of ice research. On one hand, the rising temperatures have resulted in decreased interest in traditional ice phenomena, particularly in regions where colder conditions were once prevalent. As

temperatures continue to rise, certain countries have witnessed a reduction in the frequency and extent of ice-related phenomena, leading to a diminished focus on ice research in those areas.

On the other hand, these same climate changes have generated entirely new areas of study, driven by increasingly unpredictable climatic events. The acceleration of ice melt, shifts in seasonal patterns, and the emergence of novel phenomena like mid-winter ice jam processes, more accessible Arctic regions for natural resources exploration, and the increasing demand for renewable offshore energy sources have sparked a renewed interest in understanding the dynamics of ice in changing environments. These new challenges create opportunities for innovative research into how altered climate patterns affect ice behavior, river and sea ice dynamics, and associated hydrological risks, calling for a rethinking of traditional models and approaches to ice studies.

2. Symposium in Gdańsk

Due to the significant engagement of Tomasz Kolerski in river ice studies and his role as Chair of the IAHR Technical Committee (Ice Research and Engineering Committee) since 2022, the opportunity to host the 2024 symposium at Gdańsk University of Technology was awarded. Organizing such a prestigious event entails the responsibility of ensuring the highest standards in both scientific content and organizational quality.

The 27th IAHR International Symposium on Ice took place in Gdańsk, Poland, from June 9th to 13th, 2024. It was organized by the Gdańsk University of Technology, specifically by the Department of Geotechnical and Hydraulic Engineering. Tomasz Kolerski served as the chair of the symposium, while Parisa Radan acted as the main secretary.

The local organizing committee of the 27th IAHR International Symposium on Ice was composed of the following members: Wojciech Artichowicz, Beata Jaworska-Szulc, Joanna Kaliszuk, Patrycja Mikos-Studnicka, Krzysztof Szarf, Katarzyna Weinerowska-Bords, Maciej Wróblewski, Witold Tisler, and Bogusław Pawłowski, a faculty member of Nicolaus Copernicus University in Toruń (NCU), who also contributed to the committee. All members, except for Dr. Pawłowski, are affiliated with Gdańsk University of Technology (Gdańsk Tech).

In addition, a group of dedicated volunteers played an essential role in organizing the final event of the 27th IAHR International Symposium on Ice. The volunteers included Weronika Choińska, Alicja Kąkol, Julia Kolerska, Jakub Latkowski, Natalia Maciołek, Michał Nazimek, Martha Ninsiima, Szczepan Stawski, Łucja Skibicka, Kamil Ratka, and Weronika Wiraszka. These volunteers were students from the MSc. Eng. programme in environmental engineering at the Faculty of Civil and Environmental Engineering of Gdańsk University of Technology, as well as from the University of Gdańsk and WSB Merito University in Gdańsk.

The 27th IAHR International Symposium on Ice in 2024 covered a broad range of topics related to ice research and its impact across various disciplines. The key themes of the event were:

1. **Ice Mechanics and Hydraulics** – This theme included the study of the mechanical properties of ice, both in the field and through laboratory experiments. Discussions also focused on hydraulic processes in ice-covered waters, as well as mathematical modeling of these phenomena.

2. **River, Lake, and Reservoir Ice** – Key topics included river ice processes, formation and breakup, ice jamming, hanging dams, and the operation of reservoirs during winter. Mathematical modeling, along with field and laboratory experiments, were highlighted as vital tools for understanding these complex systems.
3. **Ice Interaction with Structures** – This theme explored the ice loads on structures, thermal effects, ice forces exerted by ice floes, and the impact of ice pile-ups on infrastructure.
4. **Shipping in Ice** – Discussions in this area covered the design of icebreakers, the monitoring of ships, and the modeling of ship movement through ice-covered waters.
5. **Sea Ice Dynamics** – Topics in this session included the occurrence and dynamics of sea ice, prediction and forecasting, ice ridges, iceberg drift, and laboratory experiments. An innovative focus was on a peridynamic approach to sea ice modeling, which helps to better understand its behavior and interaction with structures.
6. **Environmental and Ecological Consequences of Climate Change in the Cryosphere** – This session focused on the impact of climate change on the cryosphere, examining environmental and ecological consequences for ecosystems in ice-covered regions.
7. **Baltic Sea Offshore Wind Development** – Chaired by Hayo Hendrikse from Delft University of Technology, this special session addressed the development of offshore wind in the Baltic Sea. The session discussed the challenges and opportunities of harnessing renewable energy from wind in an area historically impacted by ice dynamics, raising considerations for ice interaction with offshore wind infrastructure.

These sessions reflected a comprehensive approach to current issues and innovations in ice research, with an emphasis on real-world applications and sustainability.

The scientific committee of the 27th IAHR International Symposium on Ice included eleven members:

- Paul Barrette (Canada),
- Xinlei Guo (China),
- Hayo Hendrikse (Netherlands),
- Agnieszka Herman (Poland),
- Knut Høyland (Norway),
- Tomasz Kolerski (Poland),
- Raed Lubbad (Norway),
- Junji Sawamura (Japan),
- Hung Tao Shen (USA),
- Jukka Tuhkuri (Finland),
- Qingkai Wang (China).

Dr. Paul Barrette is a vice-chair of the IAHR Technical Committee on Ice Research and Engineering since 2022. He is a project manager and research scientist in National Research Council of Canada. He is an author of over eighty scientific papers considering ice mechanics. Prof. Xinlei Guo works at the China Institute of Water Resources and Hydropower Research (IWHR). He is a base member of IAHR. His academic achievements reach over eighty publications focusing on hydraulic and ice engineering as well as water resources management. Dr.

Hayo Hendrikse is an associate professor at the Delft University of Technology. He is an author of over sixty research publications. Among others his research subjects consider ice-structure interactions and climate influence on ice formation in rivers. He is a member of the IAHR TC on Ice Research and Engineering Committee. Prof. Agnieszka Herman is an expert in numerical modeling of ice and sea dynamics. She has published over hundred scientific papers considering numerical modeling of ice phenomena and sea dynamics. She is an employee at the Institute of Oceanology of Polish Academy of Sciences. Professor Knut Høyland works at the Department of Civil and Environmental Engineering of the Norwegian University of Science and Technology. He is an author of almost two hundred research publications in the subject of ice and ice drift. Professor Tomasz Kolerski, who is also a chair of the current Symposium, works at the Department of Geotechnical and Hydraulic Engineering of Gdańsk University of Technology. He is an institutional member of IAHR. His achievements in ice and water research reach over eighty scientific papers devoted to numerical modeling of ice dynamics and water management. Professor Raed Lubbad works at the Department of Civil and Environmental Engineering of the Norwegian University of Science and Technology. He is an author of nearly eighty research and conference papers considering ice problems. Professor Junji Sawamura is a base member of the IAHR. He is an associate professor at Osaka University. He is an author of over ninety research papers committed to problems of ships and ice interactions. Professor Hung Tao Shen from the Department of Civil & Environmental Engineering at Clarkson University is an expert in cold regions hydraulic engineering. He has authored over two hundred papers focusing on mathematical modeling of ice. Professor Jukka Tuhkuri works at the Department of Mechanical Engineering of the Aalto University. His expertise is the field of ice mechanics and arctic marine technology. He has published nearly two hundred academic papers considering the research on ice, ice loads and modeling of ice mechanics. Qingkai Wang is an associate professor at Dalian University of Technology. He is an author of over forty academic publications considering the subjects of ice.

The keynote lectures were given before the Symposium sessions by world recognizable experts with remarkable achievements in the field of ice research. Keynote speakers of the 27th IAHR International Symposium on Ice were:

- Wojciech Majewski,
- Hung Tao Shen,
- Christian Haas,
- Zbigniew Kundzewicz,
- Shunying Ji,
- Selda Oterkus,
- Matti Leppäranta.

Professor Shunying Ji from the Dalian University of Technology is an expert in applications of discrete element method to cold region offshore engineering and soil mechanics. He is an author of over two hundred journal papers. Matti Leppäranta is a professor emeritus of Institute for Atmospheric and Earth System Research at University of Helsinki. Author of over four hundred academic publications in the topics of ice and cold region oceanography. Professor Wojciech Majewski from the Institute of Hydroengineering of Polish Academy of

Sciences, a senior member of IAHR is an expert in hydro-engineering and water management. An author of over fifty scientific publications devoted to hydro-engineering and water management including ice related problems. Professor Zbigniew Kundzewicz is an expert in the field of climate change. A member of The Polish Academy of Sciences. An author of many publications devoted to climate change and hydrology. Dr. Christian Haas is a professor of Sea Ice Geophysics and Remote Sensing at the University of Bremen and the Head of the Sea Ice Research Group at the German Alfred Wegener Institute for Polar and Marine Research. He is an expert in electromagnetic ice thickness measurements. His main research focus is the role of Arctic and Antarctic sea ice in the climate, eco- and human systems. He is an author of over six hundred publications concerning Arctic and ice-related topics. Professor Selda Oterkus from Naval Architecture, Ocean and Marine Engineering at University of Strathclyde. Currently she is chair and the co-director of PeriDynamics Research Centre. Her main research focus is multi-physics modeling of materials and structures, which among others this includes fluid-structure interaction and ice-structure interaction modeling.

The 27th IAHR International Symposium on Ice was held under the honorary patronage of the Rector of Gdańsk University of Technology and the Polish Waters State Water Holding (PGW WP). These patronages underline the significance of the event, both within the scientific community and the industry, emphasizing its importance to water management and environmental engineering.

The 27th IAHR International Symposium on Ice was financially supported by two key funding programs:

1. **Carbonium Supporting Conferences Program** – This initiative is designed to enhance the international profile of Polish scientific institutions by supporting conferences that focus on interdisciplinary research. It aims to promote scientific exchanges, foster collaborations, and provide a platform for presenting cutting-edge research. The program ensures the financial backing of significant international conferences that align with the scientific priorities of Polish research centers.
2. **Excellence in Science 2 Program (Doskonała Nauka 2)** – This program, managed by the Polish Ministry of Science and Higher Education, supports high-level scientific projects and fosters international collaborations. Its goal is to encourage excellence in research and contribute to the advancement of science in Poland, funding initiatives that support the development of research infrastructure and promote global scientific cooperation.

These programs played a vital role in the success of the symposium, providing the financial foundation for an internationally recognized event that attracted participants from around the world. Thanks to the support from both funding programs, it was possible to offer relatively low participation fees for the 27th IAHR International Symposium on Ice, without compromising the high standard of the event. Despite the reduced fees, all attendees enjoyed the full range of benefits including meals and a guided tour on a stylized sailing ship along the Motława River in Gdańsk. Moreover, discounts were available for scientists from Poland, IAHR members, students, and researchers from low-income countries, defined by the World Bank as those with lower GDP. These initiatives aimed to increase global participation and support emerging researchers in the field of ice research.

The symposium was also proudly supported by SAMS Enterprise, a leading environmental consultancy specializing in marine projects. SAMS Enterprise provides tailored solutions for complex marine challenges, particularly in aquaculture, marine renewables, and environmental assessments. With their multidisciplinary expertise, they integrate rigorous scientific analysis and innovative approaches to ensure sustainable marine operations. Their involvement highlights their commitment to advancing scientific collaboration and knowledge exchange, particularly in the fields of ice and marine dynamics.

For many years, the Ice Symposium has offered an award for the best young scientist, which is regarded as a prestigious distinction, often opening doors to renowned scientific institutions. To participate in the competition, applicants must not hold a doctoral degree at the time of their presentation, must present their work as the first author, and must be under 35 years of age. The competition committee consists of members from the scientific committee as well as members of the IAHR Ice Research Section. This year, the award was presented ex aequo to two young scientists: Henrik Fiser from UiT – The Arctic University of Norway for his work *Iceberg Drift Trajectories in the Barents Sea, from Remote Sensing*, and Arash Rafat from Wilfrid Laurier University for his research *In-situ Thermodynamics of Lake Ice Decay*.

In recognition of his numerous outstanding technical contributions to the field of ice engineering and research, as well as his long-term support of IAHR activities, the Committee on Ice Research and Engineering proudly presented the 2024 **Ice Research and Engineering Award** to **Prof. Matti Leppäranta**.

Prof. Leppäranta has been a dedicated member of the IAHR Technical Committee on Ice Research and Engineering for many years, during which he also served as its Chair. His leadership and expertise have been instrumental in advancing the field of ice research, and his significant contributions have had a lasting impact on both the scientific community and the IAHR organization. This prestigious award, granted every two years, recognizes exceptional individuals for their achievements in ice research and engineering, as well as their contributions to IAHR's mission.

All detailed information about the 27th IAHR International Symposium on Ice can be found on the specially dedicated conference webpage: https://iahr-ice.org/

3. Symposium in numbers

3.1. Time and dates

The timeline of the symposium ranges from February 1, 2023 when the first call about the Symposium was sent, until the June 13. 2024. The important dates concerning the symposium are displayed in the Table 1 (https://iahr-ice.org/index.php/important-dates/).

Table 1. Important dates

Index	Event	Date
1	First call	Feb. 1, 2023
2	Second call	Jun. 15, 2023
3	Abstracts submissions opened	Sep. 15, 2023

4	Abstracts submissions closed	Dec. 9, 2023
5	Notification on abstract acceptance	Dec. 22, 2023
6	Notification on special sessions	Dec. 29, 2023
7	End of full papers review process	March 15, 2024
8	Reviewed paper returned to authors for corrections	April 1, 2024
9	Final paper submission	April 20, 2024
10	Early bird registration deadline	May 1, 2024
11	**Symposium event** Registration and welcoming Opening ceremony and day 1 Day 2 Day 3 and conference banquet Day 4 and closing ceremony	**June 9–13, 2024** June 9 June 10 June 11 June 12 June 13

3.2. Participants

The Symposium was organized by the Gdańsk University of Technology (Gdańsk Tech). The organizing committee consisted of 10 employees of Gdańsk Tech and 1 employee of NCU. During the symposium, apart from the organizing committee 11 volunteers took part. All of the volunteers were MSc. students of environmental engineering at Faculty of Civil and Environmental Engineering at Gdańsk Tech as well Gdansk University and WSB Merito in Gdańsk.

The symposium gathered international representation of the ice experts from respected scientific centres. This can be concluded based on high positions in the Shanghai Ranking of many of the affiliated organizations of the participants as well as in the members of the scientific committee. 153 participants took part in the conference: 137 participants in person and 16 online. The participants came from 14 countries (including Poland). Fig. 3.1 displays the number of participants by country of affiliation. The largest number of participants came from Canada (32), followed by China (24), Finland (19), Poland (17), Norway (15) and Japan (8). The number of participants from the remaining countries was smaller than 4.

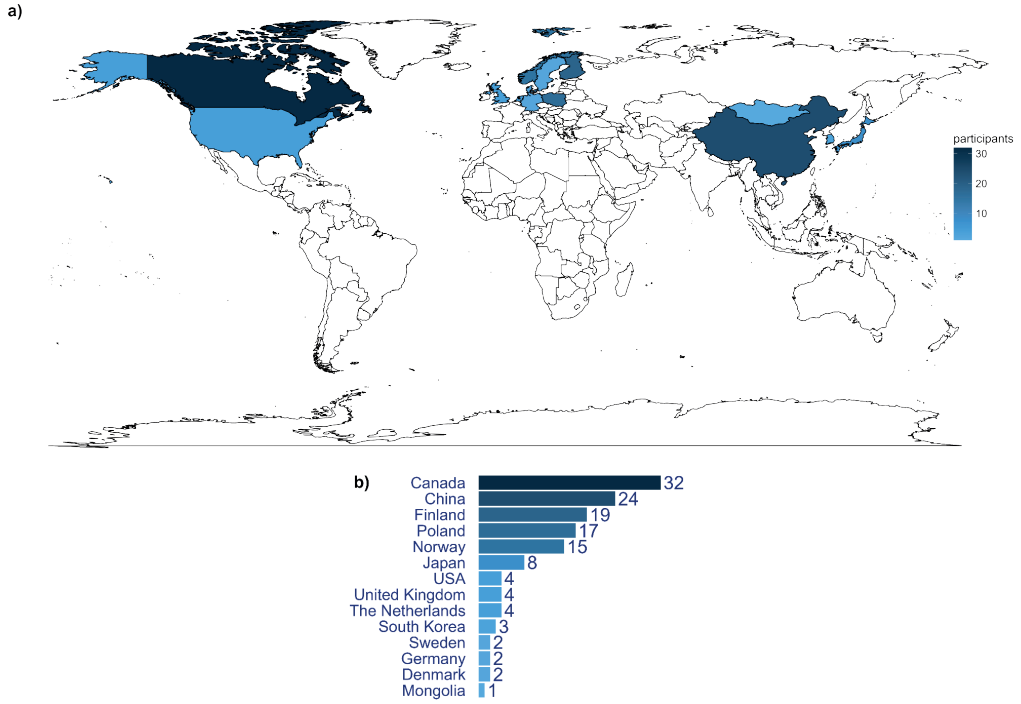

Fig. 3.1. The number of in-person participants by country a) geographical plot, b) bar plot. The colour intensity corresponds to the number of participants

For the countries from which more than four participants took part in the Symposium a plot displaying the number of participants along with their affiliations is given in Fig. 3.2.

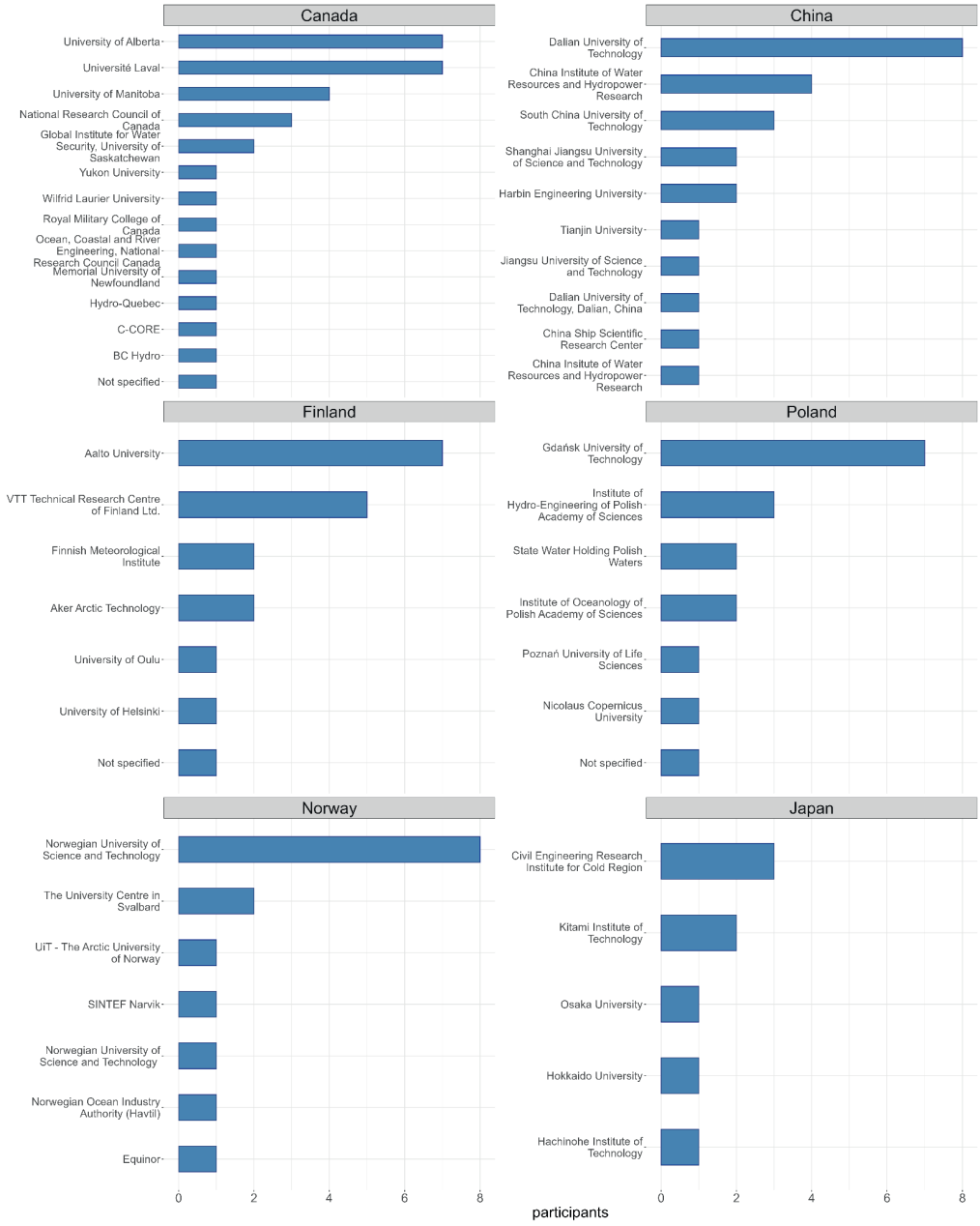

Fig. 3.2. The number of participants by country and affiliation
(only for countries with more than 4 participants)

In the scientific committee two members represented each of the following countries: China, Norway and Poland, whereas Canada, Finland, Japan, Netherlands, and USA were represented by one person. The detailed table displaying the scientific committee is given below (Table 2.). One of the members of the scientific committee also presented a keynote lecture (Hung Tao Shen).

Table 2. The members of the scientific committee with affiliations

Name	Affiliation	Country
Xinlei Guo	China Institute of Water Resources and Hydropower Research	China
Qingkai Wang	Dalian University of Technology	
Knut Høyland	Norwegian University of Science and Technology	Norway
Raed Lubbad		
Agnieszka Herman	Institute of Oceanology of Polish Academy of Sciences	Poland
Tomasz Kolerski	Institute of Oceanology of Polish Academy of Sciences	
Paul Barrette	National Research Council Canada	Canada
Jukka Tuhkuri	Aalto University	Finland
Junji Sawamura	Osaka University	Japan
Hayo Hendrikse	Delft University of Technology	The Netherlands
Hung Tao Shen	Clarkson University	USA

Among the seven keynote speakers Poland was represented by two members, whereas China, USA, Finland, Germany, and The United Kingdom each were represented by one member. The list of keynote speakers is given in Table 3.

Table 3. The keynote with affiliations

Name	Keynote lecture title	Affiliation	Country
Wojciech Majewski	Engineering and research problems connected with ice phenomena on the Lower Vistula	Institute of Hydro-Engineering, Polish Academy of Sciences	Poland
Zbigniew Kundzewicz	Climate change and its impacts – A perspective from Poland	University of Life Sciences in Poznań	Poland
Shunying Ji	Numerical Simulation of Ice Loads on Ship Hull Based on DEM	State Key Laboratory of Structural Analysis, Optimization and CAE Software for Industrial Equipment, Dalian University of Technology	China
Hung Tao Shen	Progress on river ice research	Department of Civil and Environmental Engineering, Clarkson University	USA
Matti Leppäranta	Lake Ice Melting, Deterioration and Break-up	University of Helsinki	Finland
Christian Haas	Recent advances and challenges in hydro-environmental sea ice research	University of Bremen & Alfred Wegener Institute	Germany
Selda Oterkus	Peridynamic Modelling of Ice-Structure Interactions	Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde	United Kingdom

3.3. Publications

The conference consisted of 8 parallel sessions including one common poster session. Except for the poster session, each session of presentations was preceded with the keynote lecture.

There were 147 abstract registration forms sent, 105 papers and posters were submitted from which finally the 90 works were presented during presentation sessions and 10 were presented in a poster session at the Symposium. As mentioned before 7 keynote lectures were given. Finally 93 works were published in the form of the scientific paper (Fig. 3.3).

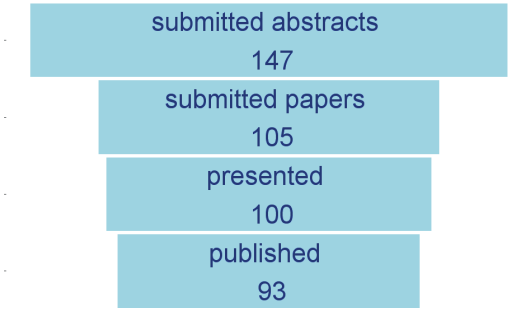

Fig. 3.3. The number of works at each stage of the conference

In terms of the number of works assigned to themes (chosen by the authors) the most popular theme was ”River, lake, and reservoir ice” with 42 presented works. The second theme was “Ice interaction with structures” with 20 papers and the third one was “Sea ice” with 17 presentations. Plot 3.4 displays the distribution of 105 conference speeches among the Symposium themes.

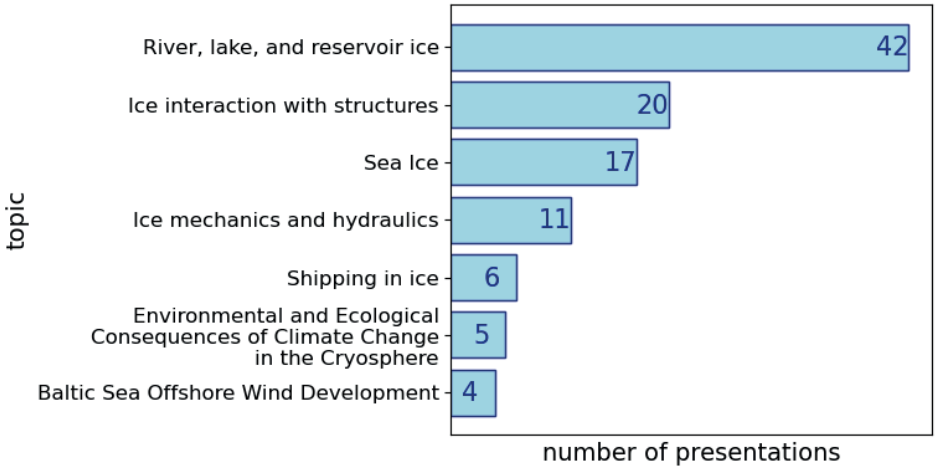

Fig. 3.4. The number of presentations held in each theme of the 27th IAHR International Symposium on Ice

In the 105 submitted works total of 452 keywords occurred, of which 334 were unique ones. In Fig. 3.5 a bar plot displaying the number of occurrences of keywords, which were used in more than one paper.

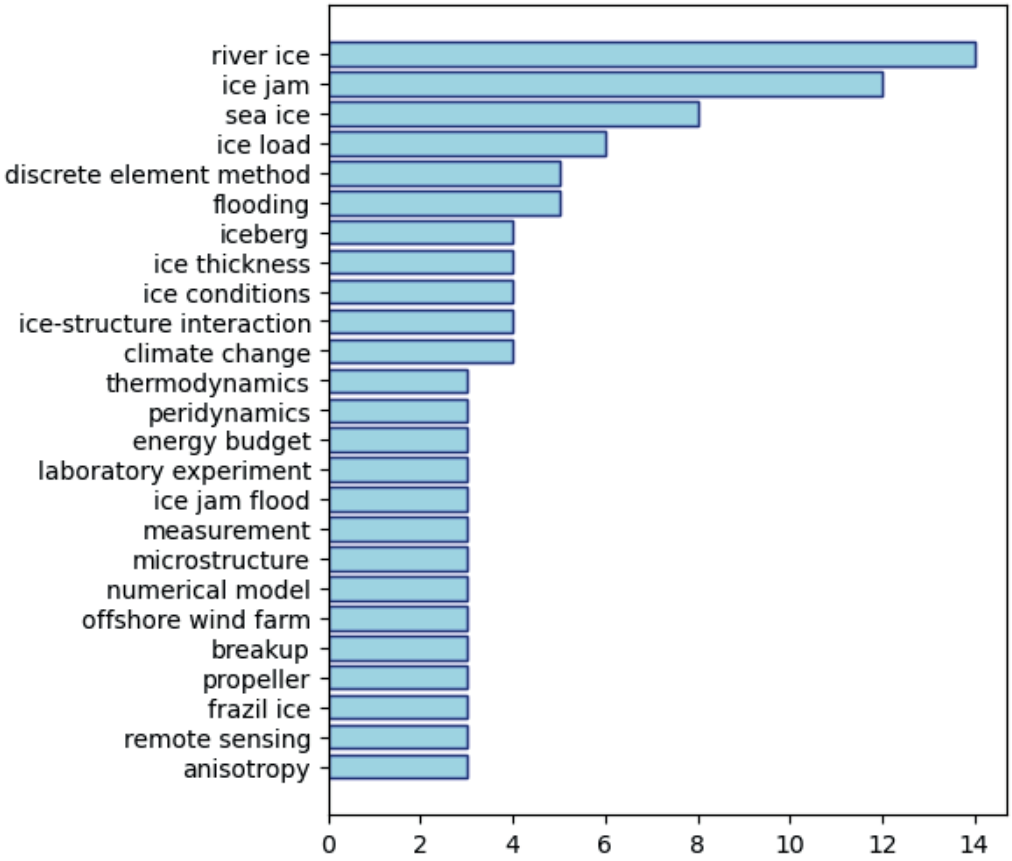

Fig. 3.5. The number of papers in which a certain keyword was used. Plot includes only keywords used more than once

Some keywords were used many times across multiple different papers. To highlight the mutual relationships between keywords occurrences a graph was constructed (Fig. 3.6). In this graph nodes represent the keywords, whereas the edges were constructed between keywords that were used at the same time in a single paper. The size of the node (as well as its label) represents the degree of the node, that is the number of edges connected to it. The widths of the edges correspond to their weights, which denote the number of occurrences of connected pairs of keywords (that is pairs that occurred in multiple works). It can be noticed that most popular nodes keywords were: “river ice”, “ice jam”, “sea ice”, “ice load”, “ice conditions”, “ice thickness”, “climate change” and “ice-structure interaction”.

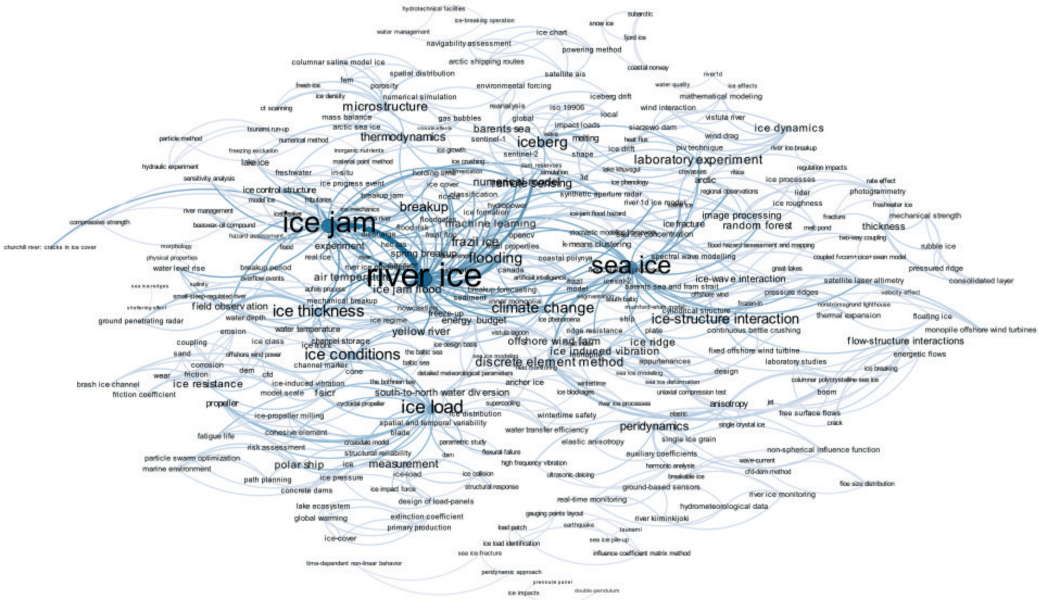

Fig. 3.6. The graph representation of the keywords' occurrences in the papers. Edges connect keywords if they were used in the same paper.

93 research presentations were published in the form of the scientific paper. The number of authors of the published papers ranged from 1 to 7, whereas on average a paper had 3 to 4 authors. The mode of the authors number per paper is 3. The distribution of the authors number among the published papers is presented in Fig. 3.7.

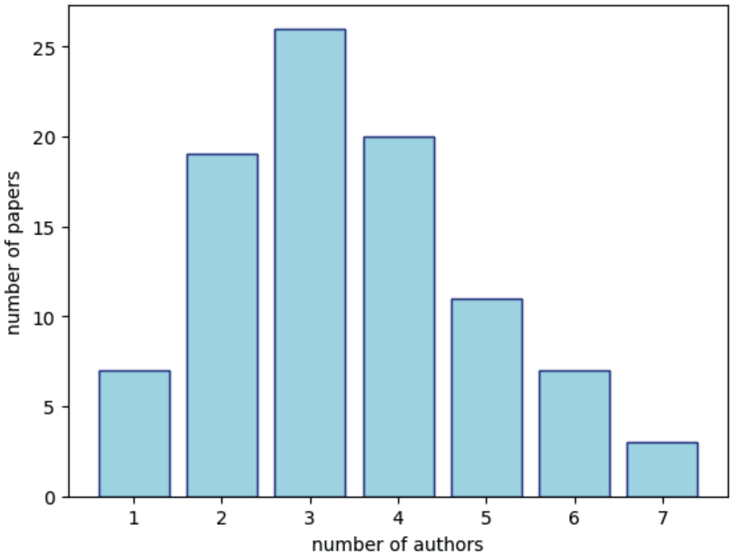

Fig. 3.7. The distribution of papers authored by a given number of authors

Among the published papers, overall 238 different authors are present. Most of the authors have authored or co-authored only one paper. On average an author was an author or a co-author of 1 or 2 papers. The distribution of paper authorships or co-authorships per author is given in the following plot (Fig. 3.8).

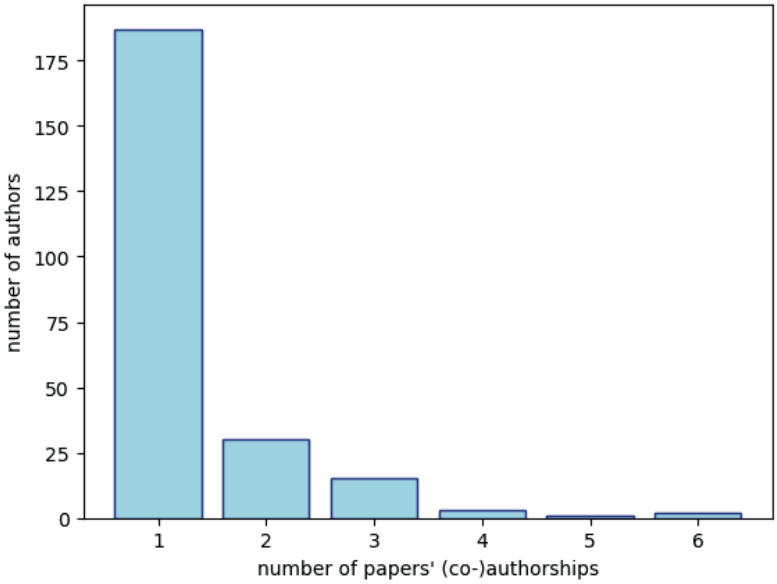

Fig. 3.8. The distribution of the number of papers authored or co-authored by an author

Three papers were published where the authors were also members of the organizing committee:

- "Mathematical Modeling of Ice Dynamics in the Area of the Planned Siarzewo Reservoir" by the committee chair Tomasz Kolerski;
- "Experimental Study on Ice Drift Under the Wind Effect" by Parisa Radan, Maciej Paprota, Wojciech Artichowicz, Tomasz Kolerski, where three authors were members of the organizing committee;
- 'February 2021 Ice Jams in the Upper Stretch of the Wloclawek Reservoir (POLAND)' by Bogusław Pawłowski.

The number of the published papers, where the authors or co-authors are members of the scientific committee is 23.

4. Conclusions

To sum up, the 27th IAHR International Symposium on Ice was an impressive collaborative event held in Gdańsk, Poland, gathering 153 scientists and industry representatives from 14 countries across the world. Organized by Gdańsk University of Technology, the symposium presented an exceptional program covering seven key areas in global ice-related issues, including ice mechanics, ice-structure interactions, environmental impacts of climate change on the cryosphere, and a special session on offshore wind development in the Baltic Sea. These subject areas attracted renowned scientists from around the globe, whose presence

on the scientific committee and as keynote speakers fostered engaging and insightful discussions, establishing the symposium as a premier platform for advancing knowledge in ice research.

The symposium also highlighted the global scope of ice research through 93 papers in the published conference proceedings, showcasing the multidisciplinary nature and diverse methodologies of the field. The presented works addressed topics ranging from sea ice and river ice dynamics to engineering challenges in polar and cold regions, underscoring ongoing research themes as well as current and emerging challenges. Furthermore, the symposium provided a valuable opportunity for building connections between institutions, promoting further collaboration and knowledge exchange.

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