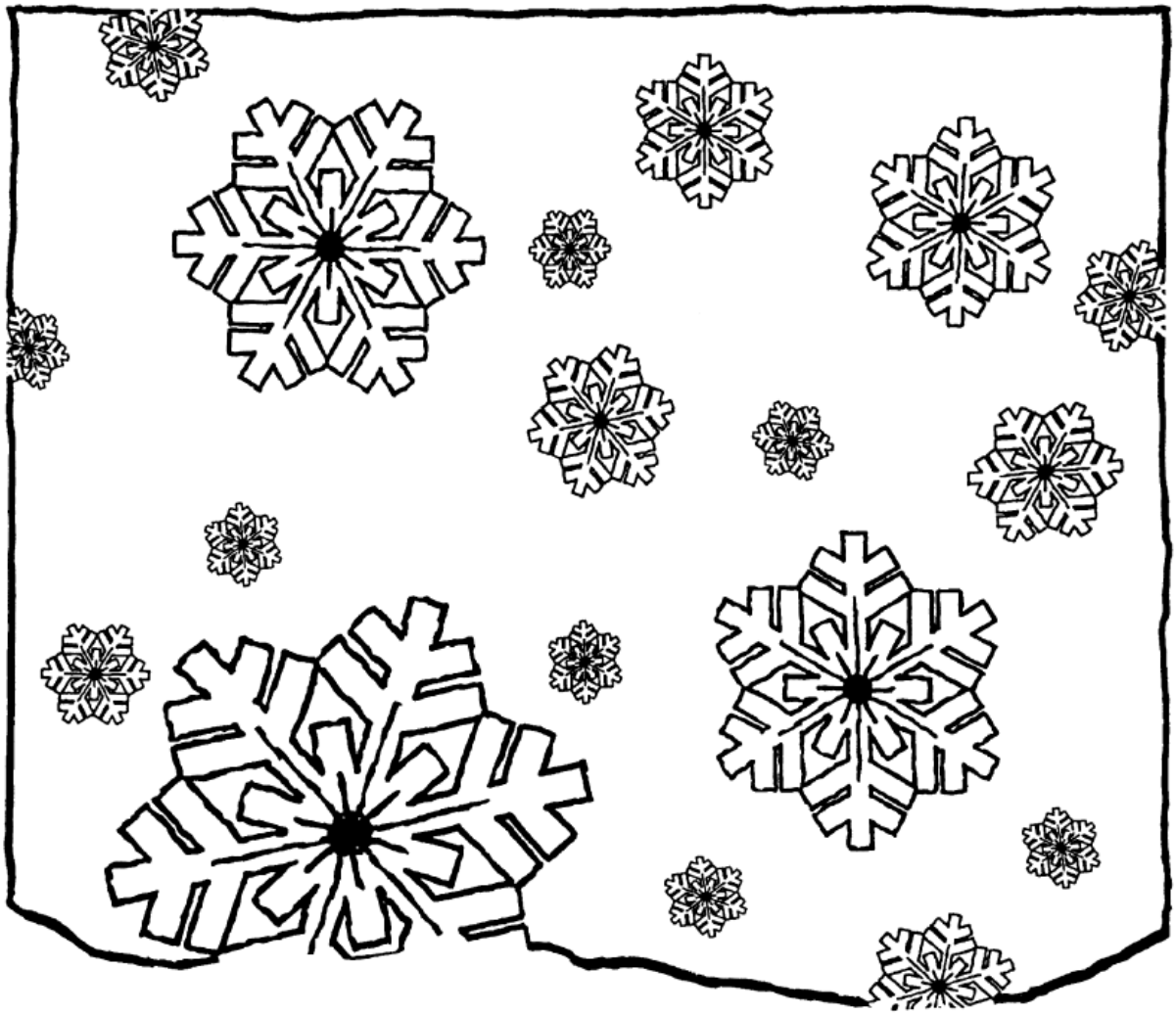

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FOREWORD

This proceedings volume contains papers presented at the 78th Eastern Snow Conference (ESC) held 1-8 June 2022 as a virtual joint meeting between the ESC, the Canadian Meteorological and Oceanographic Society (CMOS), and the Canadian Geophysical Union (CGU). The meeting featured sessions on the observation and modeling of snow processes, field measurement of solid precipitation, new approaches to snowpack measurement and general monitoring of the cryosphere, snow and ice in mountainous and Arctic regions, and snowpack properties.

The ESC is a joint United States and Canadian forum for discussing recent work on operational, applied and scientific issues related to snow and ice. It also retains an increasing interest as a symposium where novel approaches to cryospheric science of international significance are presented. The ESC has published an annual series of proceedings since 1952. Typical topics include studies of snow and ice as materials, snow removal, meteorological forecasting, river ice control, snow hydrology, snow chemistry, glaciology, remote sensing of snow and ice, and snow ecology. Membership in the ESC is open to all interested individuals and corporations. Additional copies of the current proceedings and all back issues can be obtained from the Secretary. Additional information about the Eastern Snow Conference may be found at: http://www.easternsnow.org/.

We thank members of the ESC executive committee for their continued work toward making each annual meeting a success. This includes, but is not limited to, the work of the Research Committee who evaluate all student presentations and recommend awardees for the three student prizes.

The virtual meeting was organized jointly by CMOS, CGU, and ESC. Individual sessions were supported by a team of volunteers who managed the online services and recordings. Special thanks to Andrew Ireson and Francis Zwiers for leading the Local Arrangements and Scientific Program committees, respectively.

The 2022 meeting of the Eastern Snow Conference and these Proceedings were made possible in part by Corporate membership from Campbell Scientific Canada, Geonor, Gradient Wind Engineering, and Hoskin Scientific Ltd. Printing of the Proceedings was supported by the Centre for Hydrology, University of Saskatchewan.

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We look forward to seeing you at the 79th Eastern Snow Conference meeting to be held 6-8 June 2023 at the Nurture Nature Center in Easton, Pennsylvania, USA.

Krystopher Chutko and Craig Smith
ESC Proceedings Co-Editors
University of Saskatchewan and Environment and Climate Change Canada

STATEMENT OF PURPOSE

The Eastern Snow Conference (ESC) is a joint Canadian/US organization founded in the 1940s, originally with members primarily from eastern North America. Our current members are scientists, snow surveyors, engineers, technicians, professors, students, and operational and maintenance professionals from North America, the United Kingdom, Japan, and Germany. There is a western counterpart to the ESC, the Western Snow Conference (WSC), which also is a joint Canadian/US organization.

The Eastern Snow Conference is a forum that brings the research and operations communities together to discuss recent work on scientific, applied, and operational issues related to snow and ice. The location of the conference alternates yearly between the United States and Canada, and attendees present their work by either giving a talk or presenting a poster. Most resulting papers are reviewed, edited, and published in our yearly *Proceedings of the Eastern Snow Conference*. In recent years, the ESC meetings have included sessions on snow physics, winter survival of animals, snow and ice loads on structures, river ice, remote sensing of snow and ice, and glacier processes. Volumes of the *Proceedings* can be found in libraries throughout North America and Europe, and the papers are also available through the National Technical Information Service (NTIS) in the United States and CISTI in Canada. All volumes of the Proceedings are now available at *easternsnow.org*.

* * * * * * * * *

Le Colloque sur la neige région Est (ESC) est une organisation américaine-canadienne fondée dans les années ’40 et dont les membres provenaient à l’origine principalement de l’est de l’Amérique-du-Nord. Actuellement, les membres, qu’ils soient chercheurs, techniciens, ingénieurs, professeurs, étudiants, et spécialistes des services d’exploitation et d’entretien, viennent non seulement d’Amérique-du-Nord, mais aussi du Royaume-Uni, du Japon, et d’Allemagne. Le Colloque sur la neige-région Ouest (WSC), aussi une organisation américaine-canadienne, est l’homologue de l’ESC pour l’ouest nord-américain.

L’ESC est un forum qui rassemble chercheurs et responsables des services d’exploitation pour discuter des travaux récents sur les problèmes scientifiques, opérationnels, ou autres dus à la neige et à la glace. Le site de cette réunion annuelle alterne entre les États Unis et le Canada. Les participants y présentent les résultats de leurs travaux par des communications orales ou au moyen d’affiches. Ces communications, une fois revues et éditées, sont publiées dans les *Annales de l’ESC*. Dans les années récentes, les réunions de l’ESC ont inclus des sessions sur la physique de la neige, la survie hivernale de la faune, les forces exercées par la neige et la glace sur les structures et les bâtiments, la glace de rivière, la télédétection de la neige et de la glace, et les processus glaciaires. Les *Annales de l’ESC* sont accessibles dans la plupart des bibliothèques scientifiques d’Amérique-du-Nord et d’Europe. Des copies d’articles peuvent être obtenues du National Technical Information Service (NTIS) aux États Unis et son équivalent au Canada, le CISTI. Toutes les volumes des *Annales de l‘ESC* sont maintenant disponibles sur *easternsnow.org*.

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THE PRESIDENT'S PAGE

My first Eastern Snow Conference was in 2007, hosted in St. John's, Newfoundland, and part of the first joint conference between the ESC, the Canadian Meteorological and Oceanographic Society (CMOS) and the Canadian Geophysical Union (CGU). Perhaps then it is fitting that I presided over the second such meeting in 2022. Of course, with the continued impacts of the COVID-19 pandemic, this meeting would be in an online/virtual format. Fortunately, with the lessons learned from the previous year of online conferences, we were able to create an informative, engaging, and entertaining meeting for more than 850 participants.

The scientific program included five sessions focused on snow and ice themes and were spread across three days. A total of 68 oral and poster presentations were offered encompassing a wide range of global cryosphere research. Oral presentations were conducted live over Zoom, while posters were presented using the Gather.Town app, a virtual social gathering where users could interact with others and discuss research in real time. I attempted to run the bar during the poster session, but unfortunately the app stops short of providing virtual drinks. Feedback on the virtual format was largely positive, though of course we all hoped to meet in person.

As usual, student research presentations were a highlight of the meeting; the future of snow and ice research is in good hands. I would like to send a special thanks to Sam Tuttle for organizing the daunting task of judging for our three student awards. The following students were recognized for their exemplary work:

- Megan Verfaillie, University of New Hampshire, awarded the Wiesnet Medal for best student presentation entitled "Fine-scale characterization of snowpack evolution using unpiloted aerial system lidar and SfM photogrammetry" (Wiesnet Medal and $750 cash prize)
- Alicia Pouw, Wilfred Laurier University, awarded the Campbell Scientific Canada Prize for "Evaluation of snow depth derived from ground penetrating radar on Canadian subarctic lakes" ($500 cash prize)
- Mariah Matias, Lehigh University, awarded the David Miller Award for best student poster entitled "Remote sensing of snowscapes and caribou (*Rangifer tarandus*) movement in the Northwest Territories of Canada" ($100 cash prize)

There are many people to thank for supporting my term as ESC President and the annual meeting. First and foremost is Craig Smith, ESC Vice-President, who performed double-duty as a CMOS organizer. The Local Arrangements Committee (led by Andrew Ireson and Yanping Li) and the Scientific Program Committee (led by Francis Zwiers) helped to make sure that the ESC was welcome. And a big thanks to all of the volunteers who made the meeting possible. I'd also like to acknowledge a pair of ESC Executive members who are moving on to bigger and better things: Ken Rancourt and Bart Forman. Both have played big roles behind the scenes to keep the ESC moving forward each year. Lastly, our thoughts are with ESC Executive Josh King and his family, who suffered a health emergency shortly after the meeting.

I will reiterate the comments of my predecessor here as well: the Eastern Snow Conference is committed to justice, equity, diversity, and inclusion. The ESC strives to be a welcoming venue for everyone and hopes to instill in the next generation of cryosphere researchers these important principles.

We are currently planning the 2023 ESC, the first to be held in person since 2019, in Easton, Pennsylvania, at the Nurture Nature Center. I hope to see everyone there!

Krystopher Chutko
78th President, Eastern Snow Conference

LIFE MEMBERS OF THE EASTERN SNOW CONFERENCE

The Eastern Snow Conference gratefully recognizes individuals who have made lifelong contributions to the study of snow and for their support of this organization.

JAMES FOSTER

BARRY GOODISON

GERRY JONES

JOHN METCALFE

HILDA SNELLING

DONALD WIESNET

In memoriam

PETER ADAMS

DON DUNLAP

ART ESCHNER

AUSTIN LOGAN

ROBERT B. SYKES

Wiesnet Medal

The Eastern Snow Conference encourages student research through its Wiesnet Medal. This medal is presented annually to the best student paper presented at the conference.

Year	Winner	Affiliation
2022	Megan Verfaillie	University of New Hampshire
2021	Daniela Krampe	Alfred-Wegener-Institut
2019	Zhibang Lv	University of Saskatchewan
2018	Jiyue Zhu	University of Michigan
2017	Caroline Dolant	Université de Sherbrooke
2016	Syed Mousavi	University of Michigan
2015	Nicolas Leroux	University of Saskatchewan
2014	Justin Hartnett	Syracuse University
2013	Andreas Dietz	Earth Observation Center/DFD, Germany
2012	Elizabeth Burakowski	University of New Hampshire
2011	Kathryn Semmens	Lehigh University
2010	Simon von de Wall	University of Victoria
2009	Si Chen	Dartmouth College
2008	Chris Fuhrmann	University of North Carolina at Chapel Hill
2007	*Not awarded*	
2006	Y.C. Chung	University of Michigan
2005	M. Javan-Mashmool	Université du Québec à Chicoutimi
2004	J. Farzaneh-Dehkordi	Université du Québec à Chicoutimi
2003	Alexandre Langlois	Université de Sherbrooke
2002	Patrick Ménard	Université de Laval
2001	C. Tavakoli	Université du Québec à Chicoutimi
2000	*Not awarded*	
1999	S. Brettschnieder	Université du Québec à Chicoutimi
1998	Andrew Grundstein	University of Delaware
1997	Newell Hedstrom	University of Saskatchewan
1996	Suzanne Hartley	University of Denver
1995	Paul Wolfe	Wilfred Laurier University
1994	G.E. Mann	University of Michigan
1993	G. Devarennes	Université du Québec à Québec
1992	D.W. Cline	University of Colorado
1991	D. Samelson	Cornell University
1990	A.K. Abdel-Zaher	University of New Brunswick
1989	A. Giguere	McGill University
1988	Mauri Pelto	University of Maine
1987	Cameron Wake	Wilfred Laurier University
1986	Craig Allan	Trent University
1985	Robert Speck	Rensselaer Polytechnic Institute
1984	N.K. Kalliomaki	Laurentian University
1983	David Beresford	Trent University
1982	*Not awarded*	
1981	Jeffrey Patch	University of New Brunswick
1980	Bryan Wolfe	Trent University
1979	Margaret Leech	McGill University
1978	Michael English	Trent University
1977	Don McLaughlin & George Duggan	Rensselaer Polytechnic Institute
1976	Dwayne McMurter	Trent University
1975	Nigel Allan	Syracuse University
1974	*Not awarded*	
1973	Stan Mathewson	Trent University

David Miller Award

The David Miller Award is presented to the best student poster at the annual Conference.

Year	Winner	Affiliation
2022	Mariah Matias	Lehigh University
2021	Madison Woodley	Syracuse University
2019	Gaohong Yin	University of Maryland
2018	Justin Pflug	University of Washington
2017	Elizabeth Ryan	University of Maryland
2016	Oliver Wigmore	The Ohio State University
2015	Charles Papasodoro	Université de Sherbrooke
2014	Laura Thomson	University of Ottawa
2013	Nastaran Saberi	University of Waterloo
2012	Johnathan Sugg	Appalachian State University
2011	*Not awarded*	
2010	Nicolas Svacina	University of Waterloo
2009	Iliyana Dobreva	Texas A&M University
2008	Christopher Karmosky	Pennsylvania State University

Campbell Scientific Canada Prize

The Campbell Scientific Canada prize is awarded to student research showing the most innovative use of technology in the gathering of data.

Year	Winner	Affiliation
2022	Alicia Pouw	Wilfred Laurier University
2021	Fraser King	University of Waterloo
2019	Alex Mavrovic	Université de Sherbrooke
2018	*Not awarded*	
2017	Abigail Dalton	University of Ottawa
2016	*Not awarded*	
2015	*Not awarded*	
2014	Aaron Campbell	University of Waterloo
2013	*Not awarded*	
2012	Andrew Kasurak	University of Waterloo
2011	Mathieu Beaulieu	University of British Columbia
2010	*Not awarded*	
2009	*Not awarded*	
2008	Nicholas Kinar	University of Saskatchewan
2007	Gro Lilbaek	University of Saskatchewan
2006	Gernot Koboltschnig	University of Natural Resources and Applied Life Sciences, Vienna
2005	Warren Helgason	University of Saskatchewan