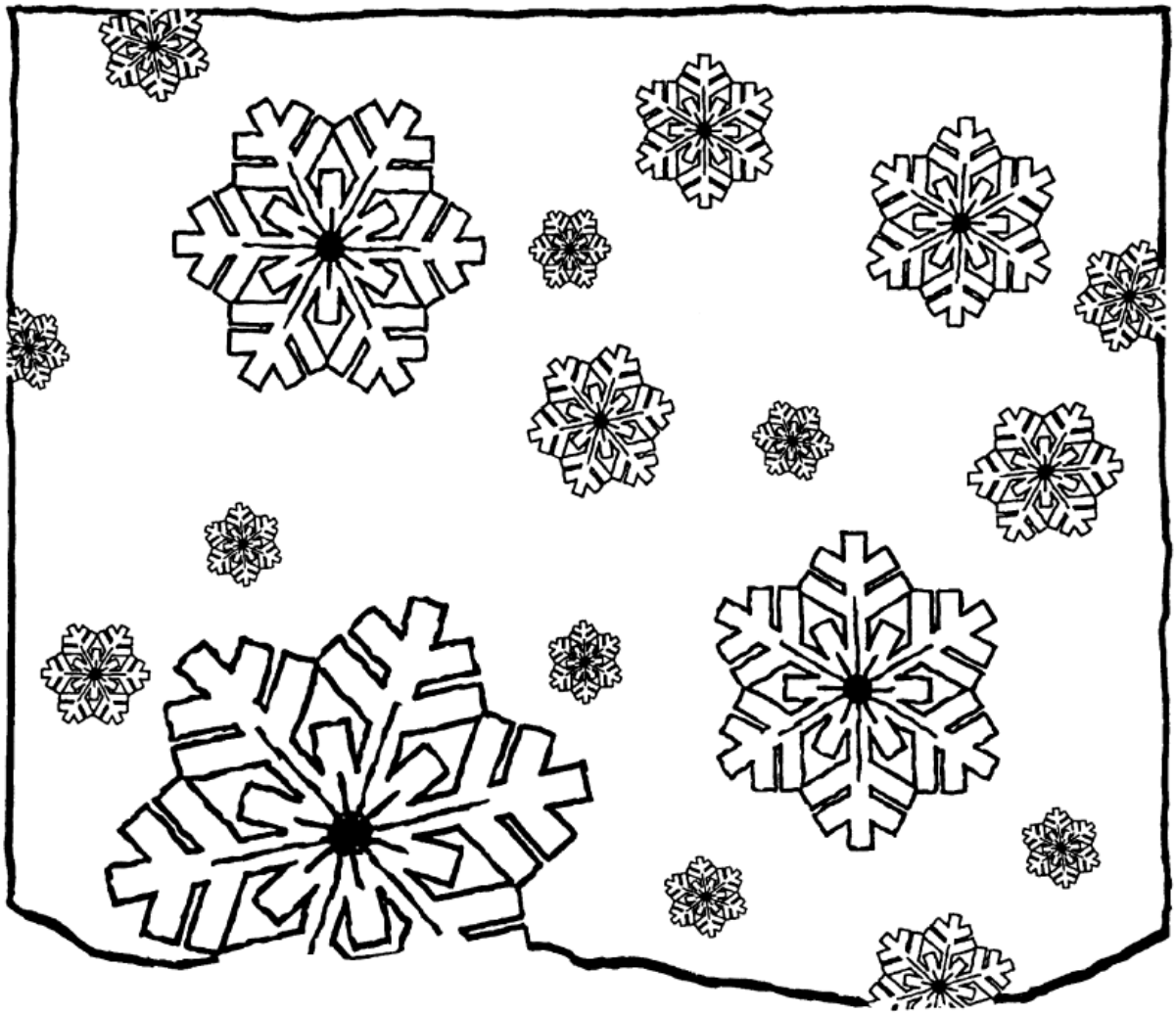

Proceedings of the
77th ANNUAL

EASTERN SNOW CONFERENCE

9 June 2021

Virtual Meeting

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Proceedings of the 77th Eastern Snow Conference

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CONTENTS

Poster Session

FOREWORD

This proceedings volume contains papers presented at the 77th Eastern Snow Conference (ESC) held 9 June 2021 as a virtual meeting hosted at the University of Saskatchewan, Canada. The meeting featured oral and poster sessions on recent advances in remote sensing, approaches to snowpack measurement, snow and ice in mountainous and Arctic regions, and snowpack properties. The meeting also included an extended discussion about the Canadian Historical SWE Dataset.

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.

Virtual meeting support for the 2021 Eastern Snow Conference was provided by Media Productions at the University of Saskatchewan in Saskatoon, SK. Special thanks to Don Warkentin and Terry Allington for assisting with the meeting.

The 2021 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.

GEONOR
Augusta, New Jersey, USA
http://www.geonor.com

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Ottawa, Ontario, Canada
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ENGINEERS & SCIENTISTS

Centre for Hydrology
University of Saskatchewan
Saskatoon/Canmore, SK/AB
Canada
https://research-groups.usask.ca/hydrology/

The 78th Eastern Snow Conference meeting will be held 1-3 & 6-8 June 2022 in conjunction with the Canadian Meteorological and Oceanographic Society and the Canadian Geophysical Union. The meeting will be held virtually.

Krystopher Chutko and Eli Deeb
ESC Proceedings Co-Editors
University of Saskatchewan and CRREL

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*.

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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

After the global COVID-19 pandemic led to both the postponement of the 2020 meeting and the inability to host an in-person meeting at York University (Toronto, Canada), the 77th Annual Eastern Snow Conference convened virtually on 9 June 2021. Despite not gathering in a familiar place as a community, we did enjoy the opportunity to see each other, albeit through computer displays, and engage on what brings us all together: a wide range of snow/ice science, research and applications.

For the 1-day virtual meeting, the organizing committee focused on highlighting student presentations. The scientific program included 5 oral sessions with 21 oral presentations, 30 poster submissions and a discussion session about the recent update to the Canadian historical snow water equivalent dataset (CanSWE). The discussion session included the unique history of compiling the dataset with feedback from the community about this valuable resource as well as continuing the dialogue on how to maintain it for both historical use and future updates. Although we look forward to the day when we will again meet in-person, the virtual meeting did allow many international students and attendees to participate. Despite not hosting a Banquet with a distinguished address and presentation of the Sno-foo Award, we did recognize the following students for exemplary research:

- Daniela Krampe, Alfred-Wegener-Institut, awarded the Wiesnet Medal for best student presentation entitled "Evaluating the Potential of the Snow Model Crocus driven by in situ and Recent Reanalysis Data for Arctic Applications" (Wiesnet Medal and $750 cash prize)
- Fraser King, University of Waterloo, awarded the Campbell Scientific Canada Prize for "Evaluation of LiDAR Snow Depth Estimates from Portable Consumer Devices and their Application Towards Advancing Citizen Science" ($500 cash prize)
- Madison Woodley, Syracuse University, awarded the David Miller Award for best student poster entitled "Using Cosmic Ray Neutrons to Estimate Snow Water Equivalent in Prairie Environments" ($100 cash prize)

The Executive Committee did hold a virtual meeting prior to the conference where we affirmed our commitment to Justice, Equity, Diversity, and Inclusion. We believe that it is critically important to establish these principals within our organization making them cornerstones in our decision-making process for executive, steering, and research committee nominations as well as within our nomination and selection process for awards. This is our opportunity to instill these principals in the next generation of cold region scientists and engineers.

Special thanks to Krys Chutko the Vice-President and Program Chair (for both the postponed in-person meetings and the virtual meeting!) as well as the University of Saskatchewan's Media Production for providing the virtual platform and technical support for the meeting. Thanks also to ESC Executive Committee Member Ken Rancourt who continues to provide outstanding leadership and is instrumental in the continued success of ESC meetings. As always, thank you to all of the members of the steering and research committees, notably Barton Forman, for virtually organizing the student presentation and poster judging. Likewise, our annual meetings and the ESC organization would not be successful without the participation and continued support of our corporate members: Campbell Scientific Canada, Hoskin Scientific, Geonor, and GradientWind.

As of this letter, we will likely host another virtual conference in 2022 based on uncertainty in travel across North America. Please check the ESC website for updates. Thank you for your participation and continued support. It has been a difficult few years for many of us, but we are in this together. Keep pushing the boundaries of your cryospheric science with the burgeoning methods and technologies available to us now and in the future. And share your work across broad audiences allowing us all to understand better the impacts on our changing cryosphere.

Elias Deeb
77th 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
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
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
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