Exploring the History of Snow Research Through the Presentations of the Eastern Snow Conference

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INTRODUCTION

In 2021, the Eastern Snow Conference (ESC) enters its eighth decade as a forum for presenting and discussing the wide variety of topics related to snow and ice research while also covering broader topics of winter conditions and seasonally/perennially frozen environments. Over this period, the technology, methodology, and language used to present this research has changed considerably, reflecting the large-scale changes observed in society in general – for example, rapid growth in transport infrastructure, near-Earth space flight, and massive changes in global telecommunications.

Since 1952, the research presented at the Eastern Snow Conference has been documented in the annual Proceedings of the Eastern Snow Conference. The papers, abstracts, and extended abstracts contained within these documents represent a history of the development of the snow and ice sciences over this period of time. In most cases, paper/presentation titles contain keywords necessary to convey the primary type, method, and/or location of research contained within the text of the paper. Therefore, they can be used as a brief summary of research and as a mean to evaluate trends in research via text mining techniques. This study evaluates the changes in words used in the ESC Proceedings to capture a glimpse of the changing approaches to research in snow and ice.

METHODOLOGY

Titles from papers and abstracts presented in the Proceedings of the Annual Eastern Snow Conference were organized by decade, from 1952-60 through 2011-2019 (there was no publication of papers in 1951 or 2020). Hyphenated words (e.g., snow-fall, sub-Arctic) and words commonly spelled in multiple ways (e.g., snow cover and snowcover) were simplified to a common form (e.g., snowfall, subarctic, snowcover). Words identifying specific locations (eg, New Hampshire = newhampshire, Saint John River = saintjohnriver) were similarly simplified. The decadal lists of titles were analyzed in *R* using the "tm" package (Feinerer *et al*., 2008). At this stage, capitalization, numbers, punctuation, and several words were removed from the lists to simplify the analysis, including common text mining stopwords lists (in both French and English: eg, la, et, par, in, as, and, ...) and words common to the literature used that overwhelmed the analysis (e.g., snow, ice). In total, 9697 words were identified from 1356 paper titles. The average title length increased from 4.9 substantive words in the 1950s to 8.8 substantive words in the 2010s.

Decadal word lists were arranged as word clouds using the "wordcloud" package in *R* (Fellows, 2018). A maximum of 200 distinct words were used in each cloud to minimize cluttering with infrequently used words. Words in the cloud were distinguished by font size and colour based on frequency of use. 35% of words were rotated 90° to facilitate packing of the word cloud.

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RESULTS AND DISCUSSION

Decadal word clouds are shown in Figure 1. As should be expected across the seven decades analyzed here, words used in paper titles have changed according to the development of the science, techniques and methods used, and the general compartmentalization of research themes. There are several words common throughout, such as “snowmelt”, “water”, and “forecast”, all of which are dominant themes in snow and ice research. However, the frequency of use of some have changed markedly through time. Snow water equivalent, or SWE, is not used in a title until 1970 but becomes dominant in the 21st century. On the other hand, “snowmelt” shows a decreasing trend in use (Fig. 2).

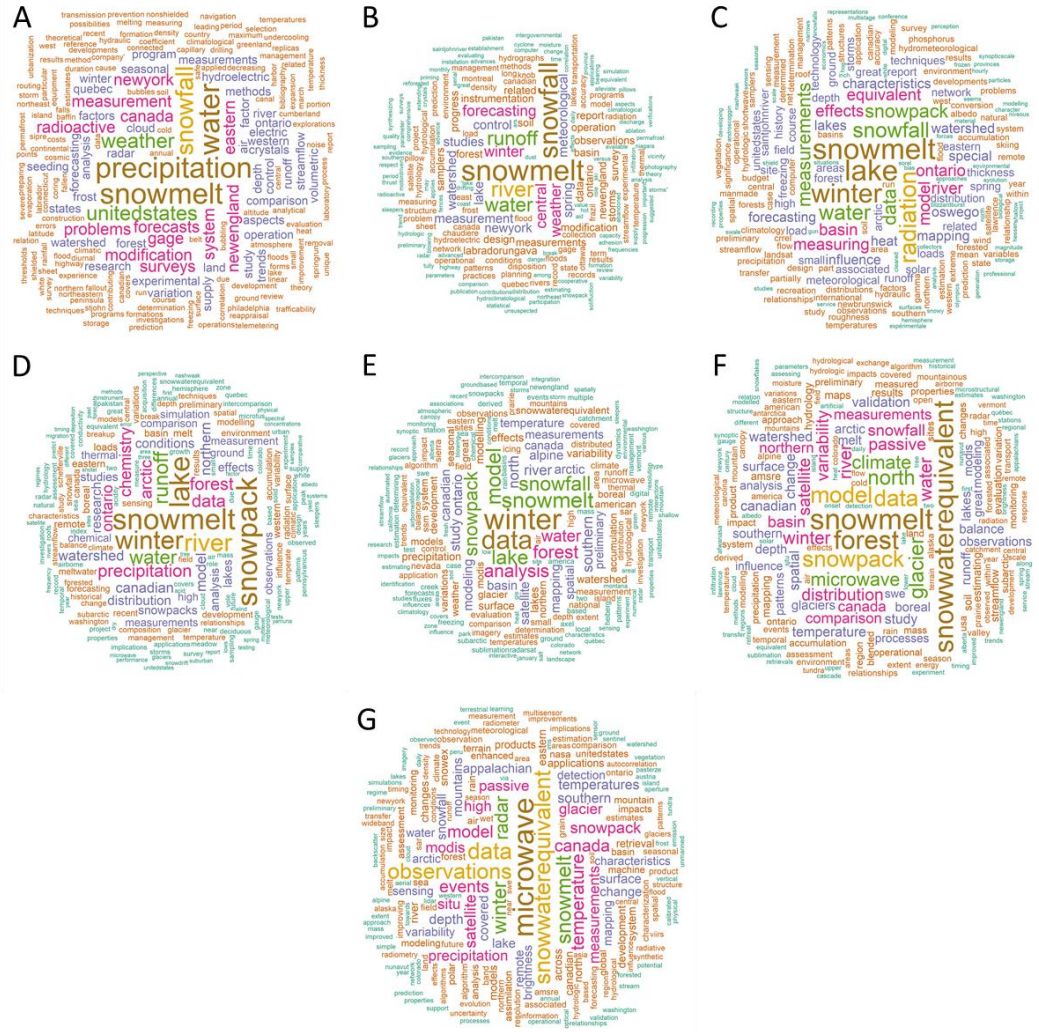

Figure 1. The frequency of words used in Proceedings of the ESC titles for A: 1952-60, B: 1961-1970, C: 1971-1980, D: 1981-1990, E: 1991-2000, F: 2001-2010, and G: 2011-2019.

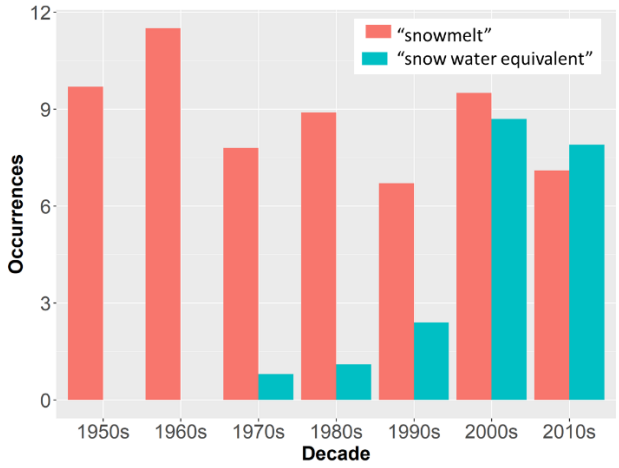

Figure 2. Variation of key term "snowmelt" and "snow water equivalent" through the history of ESC publications.

There is an overall trend is word usage that emphasizes a change in approach in understanding snowfall and snow on the ground. Early papers presented work on weather modification impacts, snowfall impacts on transportation infrastructure, and snow loading on buildings. More recently, papers have focused on process-based modeling and the variety of methods to determine large scale snow cover extent and water content. This demonstrates a fundamental change in the research presented at the Eastern Snow Conference, which had a heavy early focus on operational demands for snow data by engineers (e.g., Deslauriers, 1965), towards a more recent strong focus on process-based modeling and large-scale snow cover extent (e.g., Perry *et al*., 2013).

Despite these changes in presentation focus, the Eastern Snow Conference remains a venue to present advances in technology for the observation and measurement of snow and ice, both with respect to *in situ* and remote sensing techniques. This results in these papers recording a detailed history of the evolution of how snow and ice are measured. This can be seen in papers detailing large, motor-driven frost measurement devices (Mason and Ruggles Jr., 1954) and the radioactive snow gauge (Gerdel, 1952) through to inexpensive and portable multiparameter snowpack sensors (De Roo *et al*., 2017).

The most notable change through time in the direction of research in the Proceedings of the Eastern Snow Conference is the growth and dominance of remote sensing techniques. Of course, the early years of the ESC predate the widespread use of airborne and satellite-based sensors for snow measurement, though a rapid increase in papers using remote techniques was seen in the 1990s and continues through the present (Fig. 3). By the 2010s, "microwave" was the most commonly used word in paper titles. The increase in remote sensing-based research was accompanied by an increase in modeling-based research beginning in the 1980s (e.g., Chiang and Shen, 1982). Together, these research methods have overtaken *in situ* methods as the primary form of data collection. Although lamentable for some, this change is logical due to the increase in availability of satellite imagery, the increase in computing power, and the recognition of the high spatial variability of snowcover properties that are challenging to observe with *in situ* methods (e.g., Mann, 2018).

Lastly, spatial locator words in paper titles reveal an expansion from the tradition eastern North America home of the ESC to more globally diverse research (Fig. 4). Over the seven decades of publication of the Proceedings, changes to transportation infrastructure, global satellite coverage, and the growing online community have made it easier for researchers from all regions of the world to participate in research projects and conferences in any region. This has also resulted from a

conscious expansion of the ESC to include Arctic researchers into the ESC as they did not have a forum of their own for research dissemination, and central North American research where the snowpack is more similar to that in the east than the mountain conditions to the west (B Goodison, *pers. comm.*).

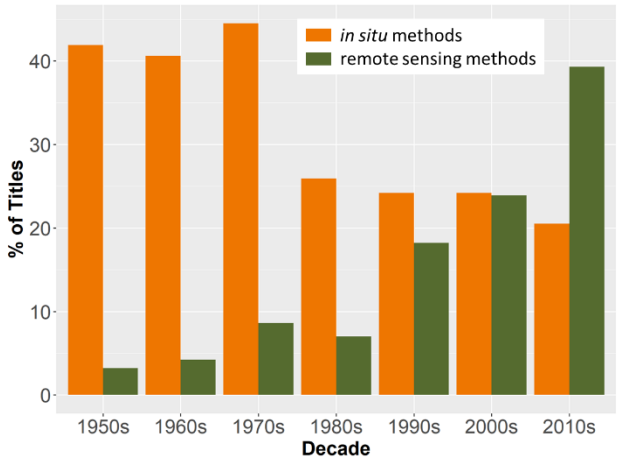

Figure 3. Variation in study methodology between *in situ vs* remote sensing research identified in ESC publications.

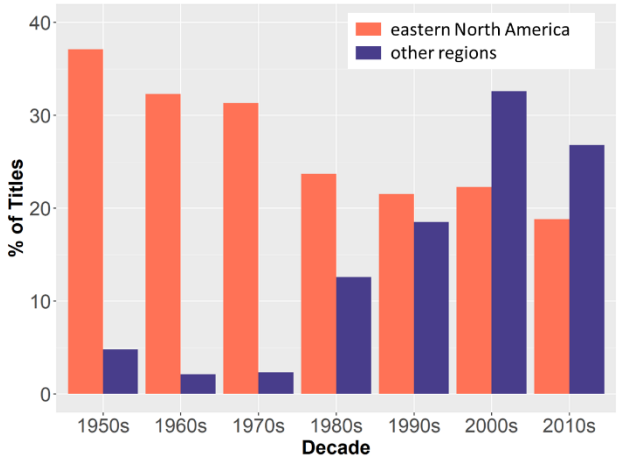

Figure 4. Variation in study spatial extent identified in ESC publications.

CONCLUSION

Since the 1950s, the Eastern Snow Conference has published papers and abstracts of the presentations at its annual meeting. These papers and abstracts represent a documentation of the history of snow and ice research and are used to highlight some of the changes observed in the discipline. These changes underline the growth and evolution of the snow and ice sciences and their response to concurrent changes in technology, scale, and, in some ways, funding availability. One of the most significant changes seen in this seven-decade record is the shift in participation from operations-based to academic-based researchers. While these two groups are often quite distinct, the research provided by each is complementary and important for the continual progression of putting

theory into practice. At approximately the same time, though not necessarily correlated, was the increased use of satellite platforms for snow and ice research. Along with this shift was the expansion of the spatial scope of Eastern Snow Conference presentations to include pole-to-pole-to-pole research.

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