The Evolution of Canada's Weather Enterprise: 150 years Anniversary Symposium

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Abstract

The virtual CMOS-MSC Symposium on 150 Years of Weather Services in Canada, took place during the CMOS Congress in 2021. It provided the opportunity to celebrate the national and international achievements in weather services delivered by the government, CMOS, academic and the private sector partnership. Participants, whose leadership and actions have guided Canada's success, shared their experiences, identified the key transformative moments, and provided their perspectives for the future of Canada's Weather Enterprise. A panel of weather enterprise leaders, many of which are Order of Canada recipients, participated in the first of three sessions. It was conducted as a Round Table discussion and reflected on significant moments. The second session focused on the forecast system with a discussion on a vision of the future and the way forward. The third session discussed the evolution of the user needs and the challenges associated to service provision, particularly in the context of emergency management. We provide here a synthesis of these three workshops,

Introduction

The Meteorological Service of Canada celebrated its 150th anniversary in 2021. While its mandate remains stable throughout the years: to provide authoritative forecasts, warnings, data, and information services related to weather, hydrological, and environmental conditions using a wide range of dissemination systems to help Canadians, public authorities, and targeted weather sensitive sectors make informed decisions about health, safety, and economic prosperity – the context in which the MSC operates has evolved significantly since the beginning. This eminent milestone provided the occasion to reflect upon the history of the Weather Enterprise in Canada, review the current state, project the view for the future, and discuss the path forward. In collaboration with the Canadian Meteorological and Oceanographic Society (CMOS), a Symposium was held consisting of one Round Table and two online workshops extending over ninety minutes each, with distinguished speakers from the public, private and academic sectors. The sessions were recorded and can be found at Science Catalogue (Canada, 2021).

The Round Table

The Round Table reflected on the significant moments in the evolution of Canada's weather enterprise. It was structured in a question and answer format. The panelists included three former Assistant Deputy Ministers of the MSC, Jim Bruce, David Grimes, and Gordon McBean; the current Assistant Deputy Minister of the MSC, Diane Campbell; two influential MSC senior meteorologists, Jim Abraham and David Phillips; and a leader from the private sector, Pierre Morrissette. All participants are, have significantly influenced upon the evolution of the Weather Enterprise in Canada and internationally. Most of the participants received prestigious recognition awards, such as the Order of Canada. The speakers were asked questions that were of a reflective nature.

The speakers provided a broad historical perspective with some commonalities. The Weather Enterprise is driven by the demands and needs for the safety, security, and socio-economics needs of Canadians and cooperation at all levels is the key to Canada's success.

Game Changing Moments

1. Hurricane Hazel (Hazel, 1954) lead to severe floods in Southern Ontario. Although the storm was well forecasted, there was no infrastructure to issue flood warnings. It was the defining event that highlighted the need to link weather, hydrology, and societal impacts. It created the opportunity for collaborative inter-disciplinary approaches which was, and continues to be the hallmark of the success of the Canadian Weather Enterprise that over time extend scientifically, and internationally involving different instances of the public and private sectors. This led to the secondment of an MSC meteorologist into the Ontario government. This marked the importance of the development and integration of scientific partnerships for hydrological emergency management. This led to the first Metropolitan Toronto and Region Conservation Authority (MTRCA) Plan for Flood Control and Water Conservation in 1959 (TRCA, 2023). This model led to the establishment of liaisons in agriculture, conservation, forestry, building, and engineering.
2. The MSC first began with a focus on providing weather information and services to mitigate the impacts of maritime disasters but continued to be driven by weather events in all seasons and in all locations. Throughout its history, focusing events such as Hurricane Hazel (Knox, 1955) , the Saguenay flood of 19 July 1996 (Milbrandt and Yau, 2001), the Ice Storm of 1998 (Henson et. al., 2007), Hurricane Dorian of 2019 (Phillips, 2020) and the $1,2B Calgary hail storm of 13 June 2020 (Phillips, 2021) have been other defining and transformative moments that remind all Canadians of the importance of MSC and the entire Weather Enterprise.

3. As the negative anthropogenic impacts on the atmosphere were recognized, Canada was one of the first, and still one of the only, nations to integrate meteorological (weather, water, and climate) and environmental sciences. In 1972, the MSC evolved from the Department of Transportation to the Department of the Environment.
4. Climate Change: The environmental concerns lead to Canada taking a prominent global role in climate change on the international stage. The MSC established a Canadian Climate Program Board and played a prominent role in the Villach 1985 Conference on Climate Change (ISC, 2018; Agrawala, 1998). This subsequently led to the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1987 and MSC staff were involved right from the inaugural meeting in Geneva (IPCC, 2023). The Toronto International Conference on Climate Change: Implications for Global Security in 1988 made the first calls for carbon emission reduction where a more coordinated approach to science and political support to address the impacts of climate change began to merge (Hare, 2009). Prime Minister Brian Mulroney and the UN Ambassador Stephen Lewis participated in the discussions. As climate change became a growing concern, the MSC drafted the Emission Control Convention and the International Framework Convention on Climate Change for the RIO summit (UNFCCC, 1992; Rio, 1992).
5. The World Meteorological Organization (WMO): There was a recognition that the only way to understand the weather and its predictability would be rooted in having access to data collected around the world. Common standards and approaches to enable the free exchange of information amongst members led to the establishment of the WMO in 1873. This had a very significant impact on Canada, creating the backbone upon which Canada relies on and contributes toward in order to effectively provide meteorological and hydrological services. The WMO evolved with time and its leadership and coordination functions have been critical to bridging science and political focus at the World Climate Conferences (WCC, 2023).
6. Canada's Place in the World: Canada's reputation, socio-economic financial situation, vast geography, and weather, and relative position on the international stage, provided opportunities to lead internationally. Canada's need for partnerships, the ability to compromise, set priorities, cooperate, and collaborate as well as their capabilities and capacities have been, and continue to be, well-respected on the global stage. Canadians play key roles at the WMO, the International Council for Science, Inter-governmental Oceanographic Commission, UNESCO, UNEP, and in the commercial marketplace. This has led to global successes by rallying the scientific community and programs towards Canadian concerns for the benefit of the global community (e.g., Global Framework for Climate Services (GFCS, 2023), Global Cryospheric Watch (GCW,

2023)). It has also provided the opportunity to share our ethics and values around the world.

Technological advances: Technology and science that made the special moments. The MSC observation and forecasting infrastructure has always been at the forefront with advances in telecommunication, super-computing, and data storage, to name a few. From a private market perspective, it's been a combination of factors involving technology and customer needs, The Weather Network/MeteoMedia became Canada's largest website, and then came mobile services. The challenge is to figure out the next growth opportunities which are based on leveraging market needs, technology, and science.

The second session was conducted in a lecture format and focused on the technical aspects of the forecast system and its future development. The weather knows no boundaries and hence monitoring and the sharing of the data globally is the core mandate of all meteorological services. Canada is geographically vast and sparsely populated. The current and future weather services need broader coverage and higher resolution from the monitoring network to meet the needs of all Canadians. Partnerships with other agencies for surface and near-surface observations; space-based Earth observations to cover land, ocean, and the Arctic; and innovations in the use of non-traditional data sources (e.g., aircraft data, mobile phones, cars) are needed.

For example, with a warming climate, the Arctic is increasingly of interest from the perspective of sovereignty, navigational, socio-economic, and recreation for Canadians. This has great consequences. It challenges the capabilities and capacities to deliver weather services. There are significant gaps in the monitoring system, the scientific understanding, and hence our numerical weather prediction and forecast systems (Jung et. al., 2016; Joe et. al., 2020) on all scales, from weather to a climate that affects the mid-latitudes and vice versa. Also, the atmosphere, the hydrological cycle, the sea ice, the land and the cryosphere are all intertwined and scientifically coupled. The majority of Canadians live in cities that have complex infrastructures that are vital to the safety of the health and socio-economy of Canadians and detailed weather service requirements in complex terrain are evolving (Grimmond, 2020; Schlünzen et. al., 2023; Joe et. al., 2023). Hence, a holistic Earth System Prediction approach at all scales, from months to decades is needed (Brunet et. al., 2015.) that Canada is well positioned to develop.

This will increase the scope of the data gathered, which is the first step, particularly related to the data sparse Arctic cryosphere. The amount of data and model outputs will explode in volume and using this data, the adaptation of the numerical weather predictions systems and interpretations model outputs will require traditional but also multi-disciplinary skills that include 'big data' and artificial intelligence techniques to leverage all the information.

Partnerships with academia will continue to play a significant role in training the next generation of weather enterprise leaders, but also in research and the development of applications. However, the partnerships need to be elevated and coordinated. Academic freedom is a core principle that must be balanced with directed research and training. A high-level weather research board was proposed during the workshop that would allow for strategic guidance but also respect for academic freedom and a competitive research proposal process.

Changing to a multi-disciplinary approach requires building bridges to overcome the gap between the individual disciplines. Articulating and understanding the vision was identified as the biggest challenge and five aspirational goals were provided as unifying themes to unite the community. They are:

1. The transition from the current suites of modeling systems to the Earth System Modelling approach in an exascale computing world.
2. The transition from the current Earth observing infrastructure to the fully integrated one.
3. Addressing the challenge of data, big data discovery, and cloud-based data processing for users to leverage AI technologies, man-machine interface. The role of the human in that is fundamental (Hoffman et. al., 2017). In order to validate the systems, we will need the feedback of people who actually work making decisions with the outputs.
4. The need to work towards and adopt a common goal amongst Canada's Weather Enterprise partners. The convergence, the critical mass working on a common goal is the key to overcoming limited resources.
5. The need to focus on the clients of tomorrow which may also include machine-to-machine interaction with smart electronic navigation system for shipping or aviation travel as two examples.

The third session consisted of presentations looking at the service provision perspective. In the early days, forecasts were disseminated by simplified codes on trains, were posted at public locations and eventually published by reluctant newspaper editors who did not value them while the public clamored for them. A recurring theme, and reiterated in the all the sessions, was that services requirements were ahead of the forecast system capabilities and provided strong motivation for the science and services communities.

Presentations by emergency management services (EMS) at both the provincial and municipal level provided clear testimonials on the benefits of the prediction and warning services for extreme weather for society. This is the primary mandate of weather services for the MSC. Weather was identified as the dominant factor in all phases of emergency response, from preparation, to response and reconstruction as EMS deals

with the cascade of downstream impacts that persist beyond the actual weather event. Provincial level EMS coordinates federal support mechanisms including funding and coordinating the local or municipal EMS agencies. Warnings and their associated uncertainly and interpretation are the first step in preparation, coordination and response. Accurate predictions lead to efficient initial response to a disaster event at the individual and neighborhood levels. Probabilistic products provide uncertainty information. EMS implicitly calibrates the information but embedded forecasters and weather support are needed to interpret the predictions as the complexity of the decision-making include non-scientific but also social-economic and political factors (Golding, 2022; Joe et. al., 2022).

The rise of the private sector and internet technology are critical to getting the warnings heard and understood by the public. Warnings are readily available via its ubiquitous presence on all the media outlets, internet, mobile and alerting notifications apps. Their key skill set is communication and out-reach and can strategically add value to the warnings by responding to specific user needs in innovative ways.

With the evolution and improvements in prediction sciences, the explosion and the availability of data and model products, the use of weather information by downstream users and decision-support systems (e.g. hydrology, health, urban transportation, urban planners, financial markets) is developing and increasing. The weather service providers will need to work in a multi-disciplinary manner from urban to climate scales from mid-latitudes to the Arctic. The current forecast paradigm is in flux and the biggest challenge is to evolve and coordinate the development of the forecast system while it continues to provide weather services for today.

Summary

The three sessions provided a view of the successes of the weather enterprise from a historical, current and future perspectives. The weather enterprise consists of partnerships at three levels of government, academia, the private sector, and increasingly, citizen science/social media.

The Canadian ability to collaborate and compromise has established its place in the world as the “honest and respected broker” to lead, and bridge ideologies to make remarkable and significant contributions internationally. Canadians have been in the leadership of the top meteorological and scientific organizations.

The needs and expectations of Canadians outstrip the operational capabilities and capacities. Advances in technology such as supercomputing, internet, data storage, radars and satellites but also user expectations drive the weather enterprise. Canada is geographically vast and diverse and there are new challenges such as the Arctic, and urban and complex terrain weather services that require an Earth System Prediction

approach from minute to decades in scale that is integrated with downstream decision-support systems. The private sector is critical in the delivery of warnings and weather services.

Canada has always been at the leading edge of designing and implementing weather forecast systems. Canada is one of the few countries in the world where weather, the environment, climate, hydrology, and the cryosphere are within a single government organization and commensurate connections and support from research and academia. Canada's forecast system is highly automated with centralized data archiving and processing, integrated modeling and forecast production. "Big data" and artificial intelligence science and downstream user applications need access to data and data products. The weather enterprise is at a crossroads as new requirements are rapidly emerging. The products and outputs will be complex, including estimates of uncertainty, and generated by chains of processing (e.g. quality control, modeling, post-processing, integrated products, tailored user products) systems. However, producing guidance and answers is not enough. Access to the underlying data and scientific interpretation in a complex decision-making environment will require greater integration and partnership with end users The weather enterprise is rapidly evolving with technology but also with new players entering the landscape. Renewing traditional partnerships, engaging new ones, and clear articulation of a unified vision and a path forward is a grand challenge for all.

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