Advancing the Canadian Geospatial Data Infrastructure: Innovations in Automation, Sustainability and Accessible Web Cartography for Mapping the Arctic's Fragile Ecosystem

Aliyan Haq [a],*, Simon Riopel [a], Peter Rushforth [a], Graham Wilkes [a]

[a] Canada Centre for Mapping and Earth Observation, Natural Resources Canada, Aliyan.Haq@nrcan-rncan.gc.ca, Simon.Riopel@nrcan-rncan.gc.ca, Peter.Rushforth@nrcan-rncan.gc.ca, Graham.Wilkes@nrcan-rncan.gc.ca

* Corresponding author

© His Majesty the King in Right of Canada, as represented by the Minister of Natural Resources, 2025.

Keywords: Accessibility, Arctic, Automation, Inclusion, Innovation, Interoperability, SDI, Standards

Abstract: The Canadian Geospatial Data Infrastructure (CGDI) is the collection of geospatial data and the standards, policies, applications, and governance that facilitate its access, use, integration, and preservation for the benefit of and use by all Canadians. To foster innovation, inclusion, interoperability, and sustainability in geospatial data particularly in support of mapping and monitoring the Arctic's fragile ecosystems and to increase the adoption and implementation of standards, Natural Resources Canada's CGDI Division is developing the following products:

Figure 1. CGDI is a collection of data, policies, standards, technologies, applications and resources to help Canadians find, use, and share geospatial information.

- Automated Harvesting Methods to Sustain Spatial Data Infrastructure (SDI) Catalogues

    o Typical standards-based geospatial data catalogues provide access to valuable geospatial content but are labour intensive and challenging to maintain. To address this, NRCan has developed an automated, evergreen Geospatial Web Services Catalogue that leverages machine learning to continuously identify, monitor, and report authoritative geospatial web services across the web for Canada and the Pan-Arctic region. It supports a range of standardized services, including OGC-compliant APIs, ESRI instances, and ISO metadata standards. This ensures up-to-date, standardized web services that are easy to locate and access, providing high-quality geospatial data for mapping to end users and the public while improving service availability and integration. This approach includes protocols for validating harvested services to ensure data accuracy and reduce systemic bias.
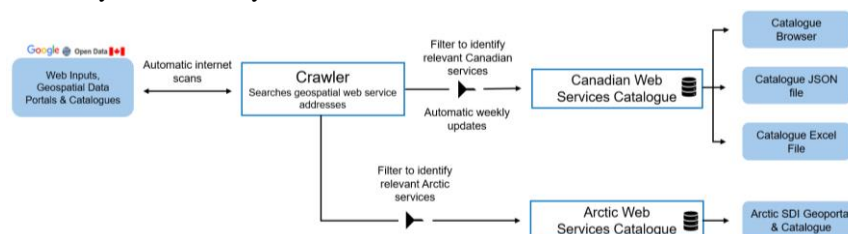

Figure 2. Web Harvesting Process: Automated identification and cataloguing of geospatial web services for Canada and the Pan-Arctic

- Pan-Arctic Wetland Inventory Baseline derived from satellite imagery and ground-truth data using a machine learning and cloud computing classification methodology

    o Led by Natural Resources Canada, in collaboration with Arctic National Mapping Agencies, Arctic Council and organisations responsible for wetland conservation, a seamless Arctic wetland's dataset over millions

2 of 2

of hectares of the landscape at a very high spatial resolution of 10 meters is being created. This initiative leverages satellite data, machine learning, and cloud techniques to facilitate wetland change detection and monitoring, supporting Arctic Council priorities and stakeholder needs to enhance conservation efforts in the Arctic.

- Map Markup Language (MapML): A proposed global standard for cartography on the web

  o The standardization of maps and location as an integrated component of modern web technologies revolutionizes the creation and use of geospatial information for all users. By enabling native support for maps in browsers, this innovation simplifies applications across fields such as education and disaster management, ensuring consistent access across platforms. Designed to operate the user-facing level of the geospatial knowledge infrastructure, it emphasizes simplicity, interoperability and broad accessibility. The Map Markup Language (MapML) World Wide Web Consortium (W3C) proposal addresses these issues, introducing a unified, accessible, and browser-native approach to representing and delivering map content. It supports multiple coordinate reference systems, including polar projections, making it well-suited for mapping high-latitude regions like the Arctic. With many existing mapping technologies, very few if any worry about integration with each other, MapML is built to integrate with existing standards such as OGC WMS, WFS, WMTS; Custom Elements; HTML web browsers; standards-based geospatial content management systems such as GeoServer, GDAL, MapServer etc. This initiative mirrors the global standardization of technologies like electrical sockets, ensuring seamless integration and use for generations.
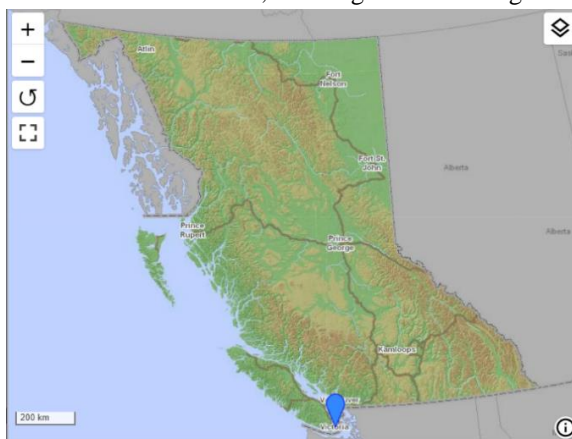

Figure 3. Map of British Columbia created using MapML

- Thematic Analysis-Ready Geospatial Starter Kits

  o NRCan confirmed through a user requirement report that geospatial data users require diverse geospatial data from different sources. Indigenous organizations are eager to increase their access to geospatial data layers and tools for land use and management purposes. In response to these findings, thematically grouped 'Starter Kits' – two national kits (Water Resources & Climate Change), one territorial kit for the Northwest Territories (NWT), and one provincial kit were developed to demonstrate how users can quickly gain access to analysis ready data for immediate mapping. The NWT kit provides access to Arctic geospatial data and services relevant for land use and resource management in northern Canada.

Through these products, the CGDI fosters innovation, inclusion, interoperability, and sustainability (AI techniques) in mapping by providing interoperable standardised geospatial datasets via the web harvester and starter kits, supporting climate change monitoring and predictive modeling with the Arctic Wetland dataset, and enabling accessible, web-friendly cartography through the MapML standard. Together, these initiatives support Arctic mapping priorities through improved access to geospatial data, automation of data discovery, enhanced baseline environmental datasets, and web-native mapping standards tailored to northern geographies.

References

Rushforth, P., 2016. Maps for HTML: A New Media Type and Prototype Client for Web Mapping. In: *WWW '16 Companion: Proceedings of the 25th International Conference Companion on World Wide Web,* pp. 543 – 548

Wilson, C., Rushforth, P., Thomas, T. & Denny, S. C. (2022). NRCan'S CCMEO introduces FAIR+: making scientific data easier to find and access to benefit all communities. *Canadian Geospatial Data Infrastructure, Information Product, 62e. https://doi.org/10.4095/329856*