

DEVELOPMENT OF THE CANADIAN COASTAL ZONE INFORMATION SYSTEM (CCZIS)

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BACKGROUND AND MOTIVATION

The Canadian Coastal Zone Information System (CCZIS) represents a pioneering endeavor aimed at enhancing coastal engineering and infrastructure decision-making in Canada. The CCZIS is a one-stop decision support system, with coastal datasets, analyses, and tools to allow for planning, design, and coastal risk assessment of marine and coastal infrastructure. The system includes modelled nearshore wave conditions, analysis of meteorological stations, long-term water level stations, sea level rise projections, among other key datasets.

This abstract outlines the development and critical milestones achieved by the CBCL-DHI team as they transition from a proof-of-concept to a functional prototype development.

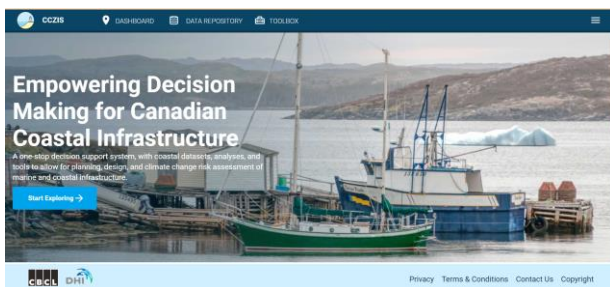


Figure 1 - CCZIS Home Page

METHODS

The team embarked on this journey by developing a user-centric, web-based, multi-tenant decision-support system to streamline access to coastal datasets and the assessment of risk, planning, and design of marine and coastal infrastructure. The system comprises of four core modules:

Map Viewer: A module which provides users with rapid access to coastal information at all Canadian small craft harbours, major ports and key coastal terminals, allowing visualization of critical data with minimal user input.

Data Repository: A centralized repository housing a diverse range of coastal datasets, ensuring easy access for users in need of relevant information. The repository supports both pre-defined and quality controlled datasets, as well as user-uploaded datasets, with defined access permissions.

Data Dashboard: An interactive dashboard that

empowers users to access key coastal data for sites of interest and extract valuable insights.

Functions Toolbox: A versatile toolbox, enabling the integration of additional tools and functionalities for addressing complex coastal engineering challenges.

The development of CCZIS has been characterized by a focus on user experience, ensuring that all modules share a common look and feel. This user-centric approach contributes significantly to the success of the project, and the high-quality outputs that are being developed for all of Canada.

The backbone of the system is based on reliable coastal data and numerical modelling outputs. First, the development includes a robust data collection, processing, standardizing, and integration strategy, covering over 20 datasets including: offshore waves and winds hindcasts/reanalysis (ECMWF-ERA5¹, MSC50², WIS³), wave buoys (Ocean Networks Canada, ECCC⁴), meteorological stations (ECCC), tide gauge stations (DFO⁵), sea level rise projections (CCCS⁶, NASA⁷), ice characteristics (CIS⁸), geotechnical information summaries (NRCan⁹), topo-bathymetric data (CHS¹⁰, local surveys), vertical separation surfaces (CHS). A major contribution of the development is the quality control of the datasets mentioned above to ensure consistency and reliability of all datasets across Canada. Post-processing includes the estimation of statistics such as mean, upper, and lower percentiles for monthly, seasonal and annual conditions. Additionally, extreme value analysis (Ferreira & Guedes Soares, 2009) of applicable datasets was carried out providing offshore and nearshore estimates of waves, winds, water levels, among other variables.

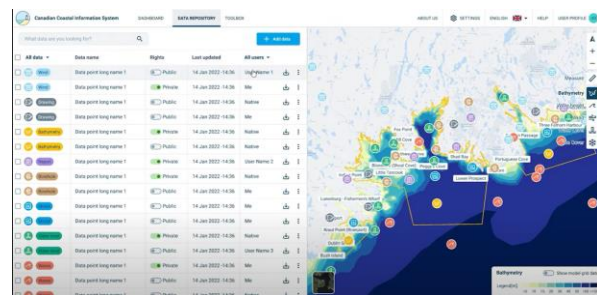


Figure 2 - Data Repository and Map Viewer with Overview of Data Sources.

¹ European Centre for Medium-Range Weather Forecasts, Fifth Generation Reanalysis (ECMWF-ERA5)

² Meteorological Services Canada Hindcast (MSC50)

³ Wave Information Study (WIS)

⁴ Environment and Climate Change Canada (ECCC)

⁵ Department of Fisheries and Oceans Canada (DFO)

⁶ Canadian Centre for Climate Services (CCCS)

⁷ National Aeronautics and Space Administration (NASA)

⁸ Canadian Ice Service (CIS)

⁹ Natural Resources Canada (NRCan)

¹⁰ Canadian Hydrographic Services (CHS)

Second, a comprehensive regional high-resolution wave modelling framework was developed to simulate extreme events and produce hindcasts of priority storms for Atlantic Canada, which will eventually be expanded to cover all Canadian coastlines. The modelling utilized a multi-domain approach, currently comprising of 24 domains across Atlantic Canada with a target nearshore resolution of 300 m. The framework for the numerical wave models follows well established modelling practices but emphasizes the efforts for standardization on interpolation methods, model mesh building steps, definition of time- and space-varying boundary conditions (Caires *et al.* 2004, Swail *et al.* 2006), numerical and physical settings (using MIKE 21 Flexible Mesh Spectral Wave model), and seamless integration into the system. The nearshore extreme wave modelling offers a valuable dataset currently unavailable in Canada. In addition to the native data and modelling results products of the CCZIS, users will be able to upload project-specific model results and integrate them into their private repository.

The map viewer in the system highlights all small craft harbours, major ports and key coastal terminals, and associates them with reliable nearshore and offshore data (Figure 3). A default overview is presented for each location, and additional information can be explored in the various data tabs (water levels, waves, wind, ice, sea level rise, geotechnical). Each tab contains the applicable data sources and the grid-cell or point location where the data is coming from. This includes, for example, sea level rise estimates obtained from CCCS and NASA, based on CMIP5 and CMIP6 projections.

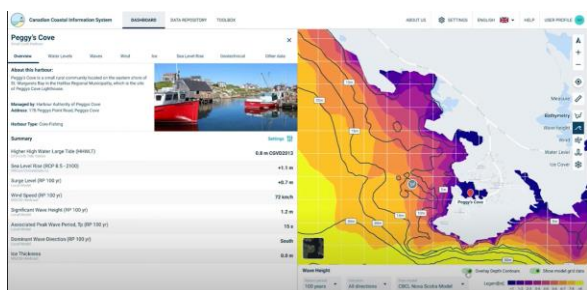


Figure 3 - Small Craft Harbour Overview Tab and Map Viewer with Nearshore Wave Conditions.

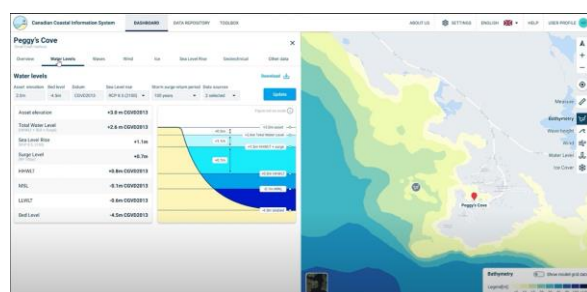


Figure 4 - Key Location Water Level Tab and Map Viewer.

An example of the associated data tabs is presented in Figure 4, illustrating the CCZIS capabilities to assess existing infrastructure and assets at different elevations with respect to the expect local extreme water levels.

The toolbox component of the CCZIS, multiple on-the-fly tools to support users, including a bathymetry interpolation tool, which allows the users to upload and visualize native data, and interpolate data by region, within a polygon defined by the user either by drawing or uploading the boundaries. Furthermore, the system includes a tool that calculates seasonal and monthly statistics for any timeseries datasets hosted in the data repository, or user uploads that meet the minimum requirements. Lastly, for areas where data is scarce, or where numerical models are not yet available (e.g. Arctic coast), a simplified 1D wave propagation model provides preliminary estimates of nearshore wave conditions. The toolboxes allow the user to download interim and final outputs in user-friendly formats for further analysis or integration for more detailed assessments.

CONCLUSIONS

The transition from a proof-of-concept to a functional prototype has been marked by substantial achievements. The team's collaborative efforts have enabled the development of a reliable, efficient, responsive and secure system architecture that embodies scalability and flexibility and allows users to visualize, download, and process reliable nearshore coastal data from a vast range of resources and system specific data analysis outputs, numerical modelling results and toolboxes. The CCZIS will be capable of managing different user profiles (with specific data access), tool capabilities, and upload/download rights. Governments, consultants, universities, and other users will be able to benefit from this one-stop decision support system to expedite their consulting projects and research initiatives.

In conclusion, the CCZIS project represents a significant milestone in supporting the enhancement of coastal infrastructure resilience in Canada. The integration of relevant coastal datasets across the nation serves as a testament to its potential to revolutionize the approach to coastal engineering and coastal infrastructure and assets decision-making.

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