Coastal Flood Hazard Tools for Newfoundland & Labrador

November 13, 2025

Ethan Slaney, B. Eng., E.I.T.
Water Resources Management Division
Department of Environment, Conservation and Climate Change
EthanSlaney@gov.nl.ca

Acknowledgement

- These projects were funded in part by the Government of Canada under the Flood Hazard Identification and Mapping Program or FHIMP
- We would also like to acknowledge DHI and C-Core as contributors to the development of these coastal flood hazard tools

Session Overview

- Background
- Atlas of Storm Surge and Wave Climates
  - Development and Deliverables
  - Limitations
  - Uses
- Coastal Flood Simulation App
  - Background
  - Uses
- Demonstration
- Questions
  - DHI and C-Core available throughout presentation

Newfoundland & Labrador

Background

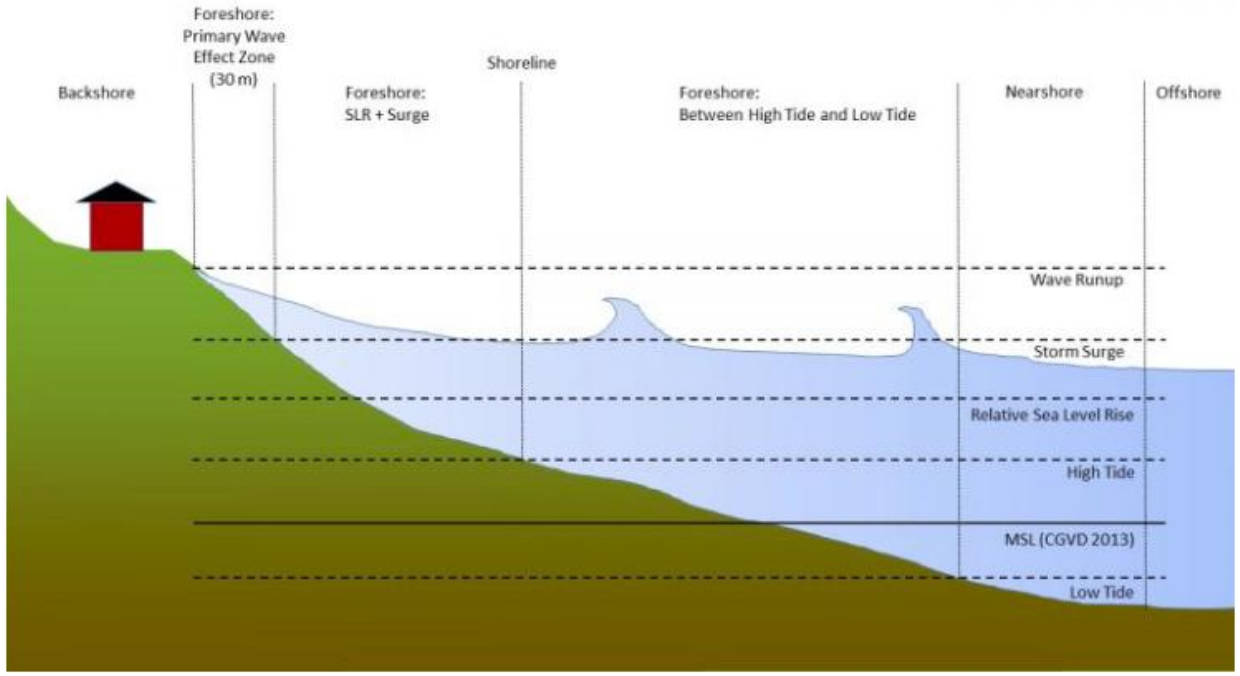
Background – Climate Change

- Effects of Climate Change:
  - Rising sea levels
  - Disappearing pack ice
  - Increased frequency and intensity of storm surge and wave events
- Projections:
  - Sea Level Rise of up to 100 cm by 2100 in parts of the province
  - Storm Surge exceeding 4 m
  - Waves over 10 m in some areas
- Impact of Climate Change:
  - Increased frequency and intensity of coastal flooding events
  - Increased damage to property and infrastructure
  - Increased risk to life in these coastal areas

Newfoundland & Labrador

Background – Coastal Water Level Monitoring vs Wave Monitoring

- Coastal water level monitoring:
  - Measures total water level at the coast
  - Tracks tides + storm surge + longer-term ocean variations
  - Used to assess flooding potential
  - Typically reported as meters above chart datum
- Wave monitoring using weather buoys
  - These offshore wave buoys can measure waves height, period, and direction
  - Waves are cyclical peaks above/below the sea level
  - A “3 m wave” does not mean the water level rises 3m
  - Important for coastal erosion, marine safety, impact analysis



Newfoundland & Labrador

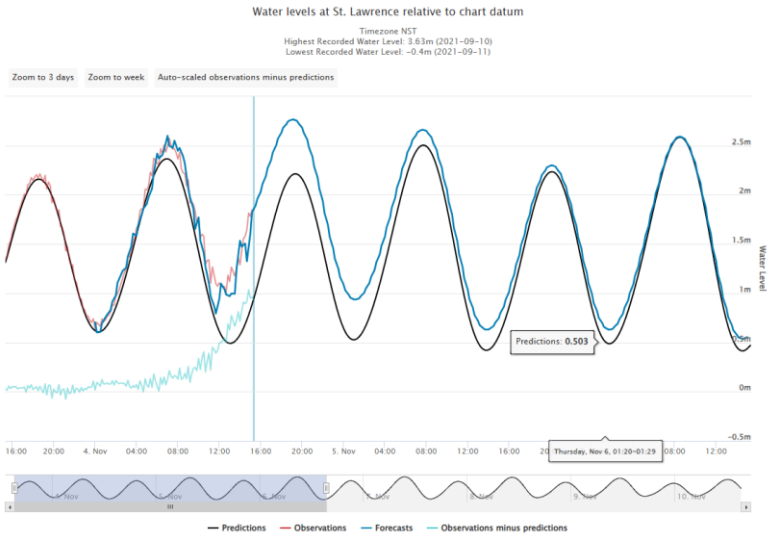
Background – Recent Events

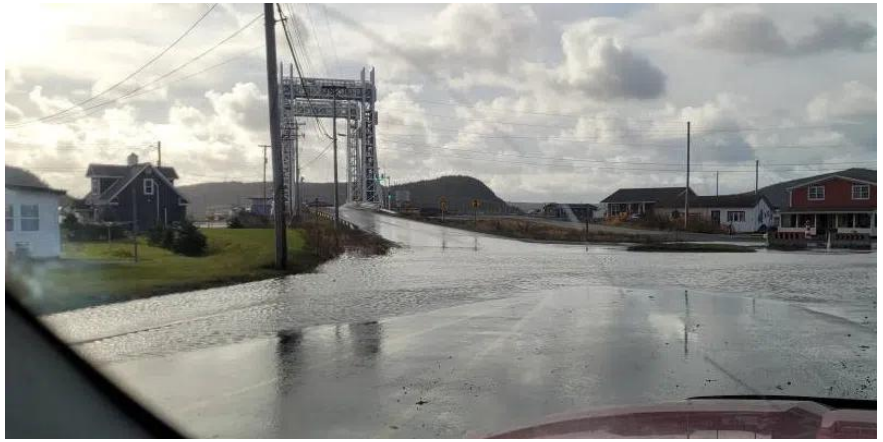
- Hurricane Fiona:
  - September 2022 in Port Aux Basque, southwest coast of Newfoundland
  - Primarily a wave event causing severe coastal flooding
  - 142 homes uninhabitable, $87 million in damages and counting, one fatality
- Gambo Flood Event
  - January 2025 in Gambo, northeast coast of Newfoundland
  - Primarily a storm surge event causing local flooding
  - Flooded homes and damage to municipal infrastructure, such as road washouts and breakwater damage, is estimated at $8 to 9 Million in noninsured damages

Newfoundland & Labrador

Background – Recent Events

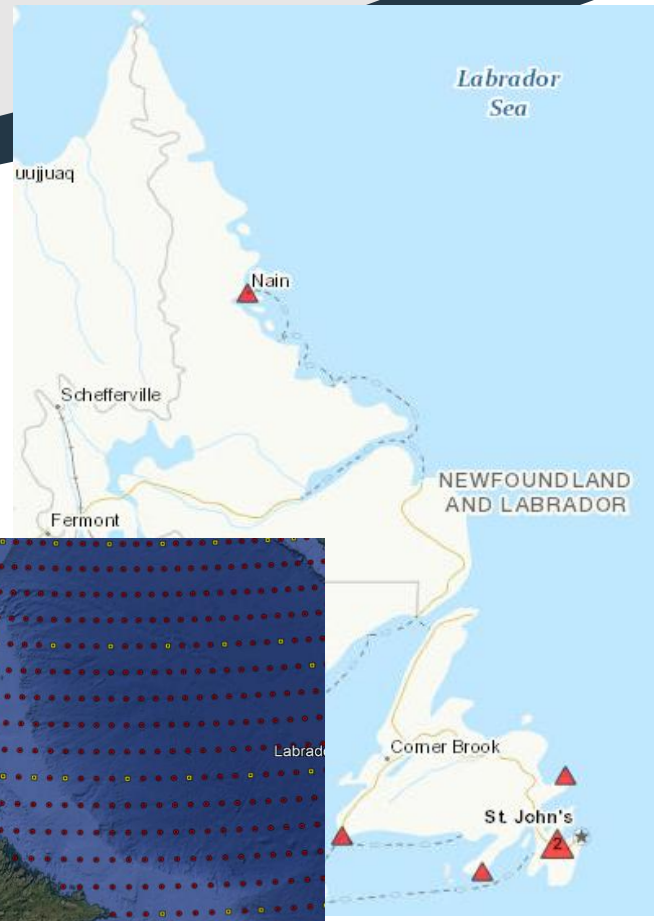
- Recent Event (November 2025)
  - At the beginning of November Newfoundland experienced another significant rainfall and storm event
  - Storm surge and waves caused flooding in several communities such as Placentia
  - The seawall that protects a critical section of roadway in Trepassey was also damaged
- Specific flood risks to coastal communities must be examined

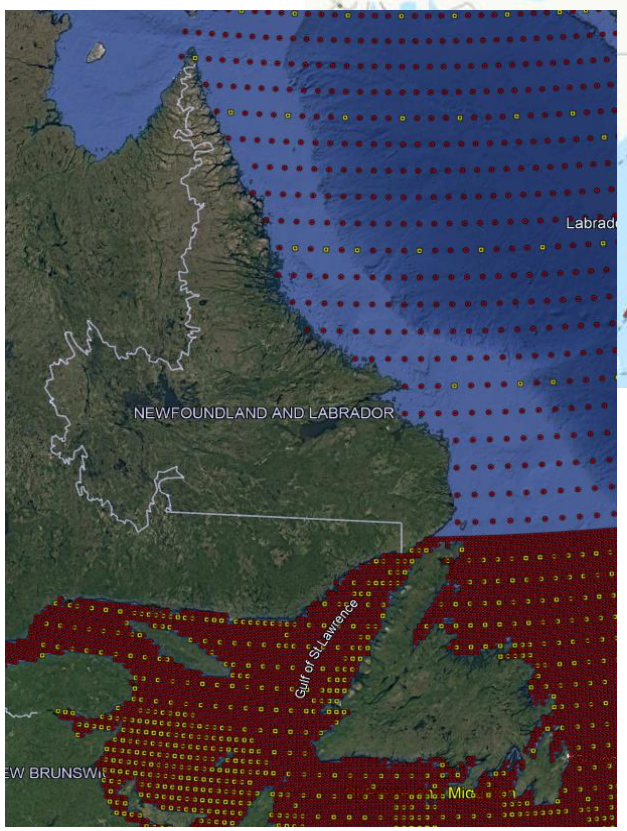




Background – Local Conditions

- NL Flood Event Inventory dating back to 1775
- Coastal flooding accounts for 20% of the province's flood events, frequency of these events increasing over time
- The Newfoundland and Labrador Atlas of Storm Surge and Wave Climates was developed as a tool to understand and mitigate these risks
- Prior to Atlas development:
  - Limited coastal water level monitoring data for NL
  - Only 6 active coastal water level stations in the province, 1 in Labrador
  - MSC50 data is sparce off Labrador coast





Newfoundland & Labrador

Atlas of Storm Surge and Wave Climates

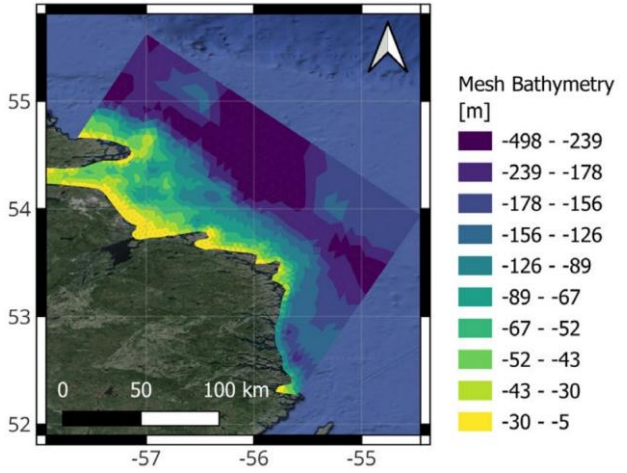
Atlas Development

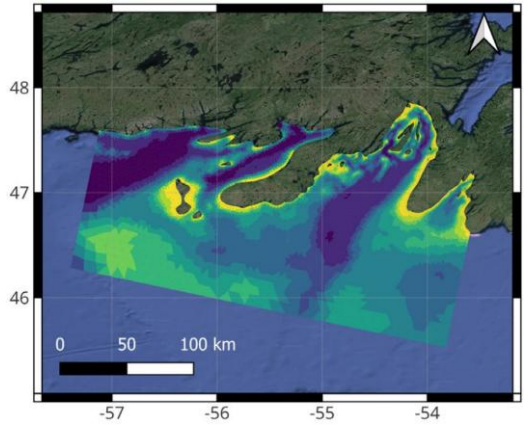
- Developed by DHI, completed in 2024
- Outputs from a series of regional hydrodynamic, storm surge, and wave models
- Includes estimates of extreme nearshore surge levels and wave conditions for the entire coast of Newfoundland and Labrador
- Purpose of the Atlas:
  - Originally, coastal water level data was needed to set boundary conditions in riverine flood models for flood mapping studies
  - Scope was expanded after Hurricane Fiona in September 2022 to include coastal storm surge and wave modeling
  - This data could be used to provide boundary conditions for coastal flood modeling and mapping in flood studies

Newfoundland & Labrador

Regional Storm Surge and Wave Model

- A regional storm surge and wave model is a specialized tool used to forecast the impact of storm surges and waves on coastal areas within a defined region
- It includes an analysis of information about:
  - Storm intensity
  - Atmospheric pressure
  - Tidal fluctuations
  - Coastal topography
  - Regional bathymetry
  - Ice coverage
- This information is used to predict the height and direction of storm surges and the size and direction of storm waves
- These models are crucial for coastal flood risk assessment and hazard mitigation

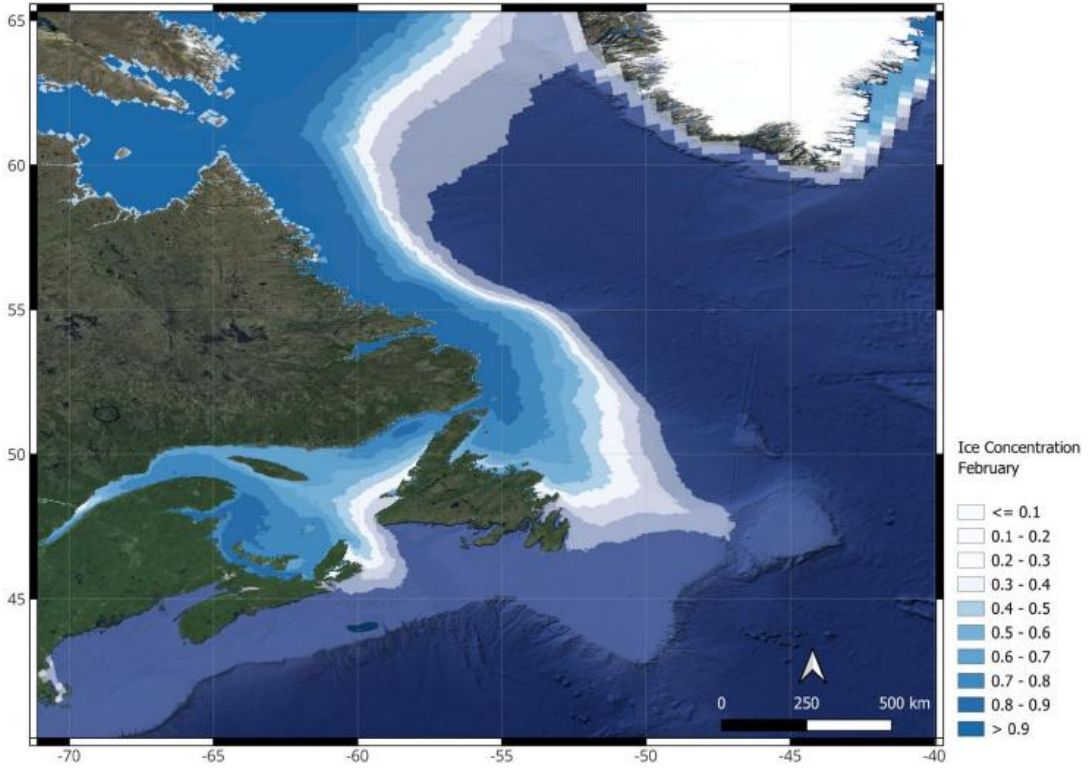




Newfoundland & Labrador

Atlas Development – Inputs

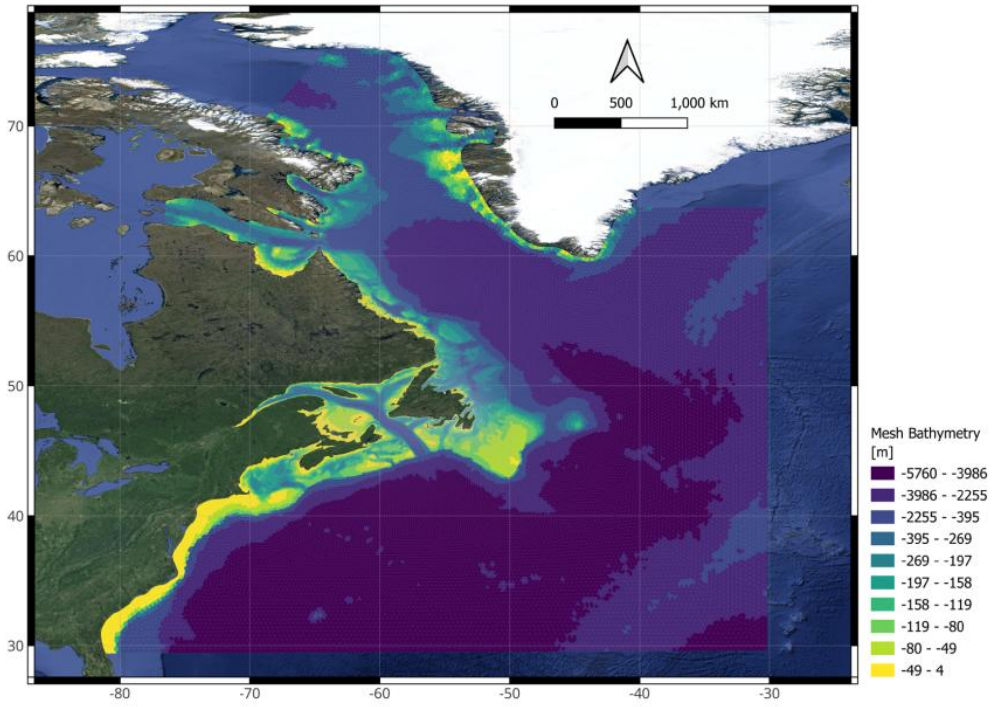
- Wind and pressure hindcast dataset driven primarily by ECMWF ERA5 historical atmospheric reanalysis
- Tidal data from DTU10 global model
- Sea ice coverage data from CIS/NSIDC,
- Offshore waves from DHI's global wave model.
- Bathymetric data obtained from NONNA, GEBCO and MIKE C-MAP



Newfoundland & Labrador

Atlas Development – Storm Surge Model

- DHI MIKE 21 FM HD
- Model covers the North Atlantic and Labrador sea
- Higher resolution around the coasts Newfoundland and Labrador
- Produces water level residuals only
- Excludes:
  - Wave setup
  - Non-linear tide-surge interaction



Newfoundland & Labrador

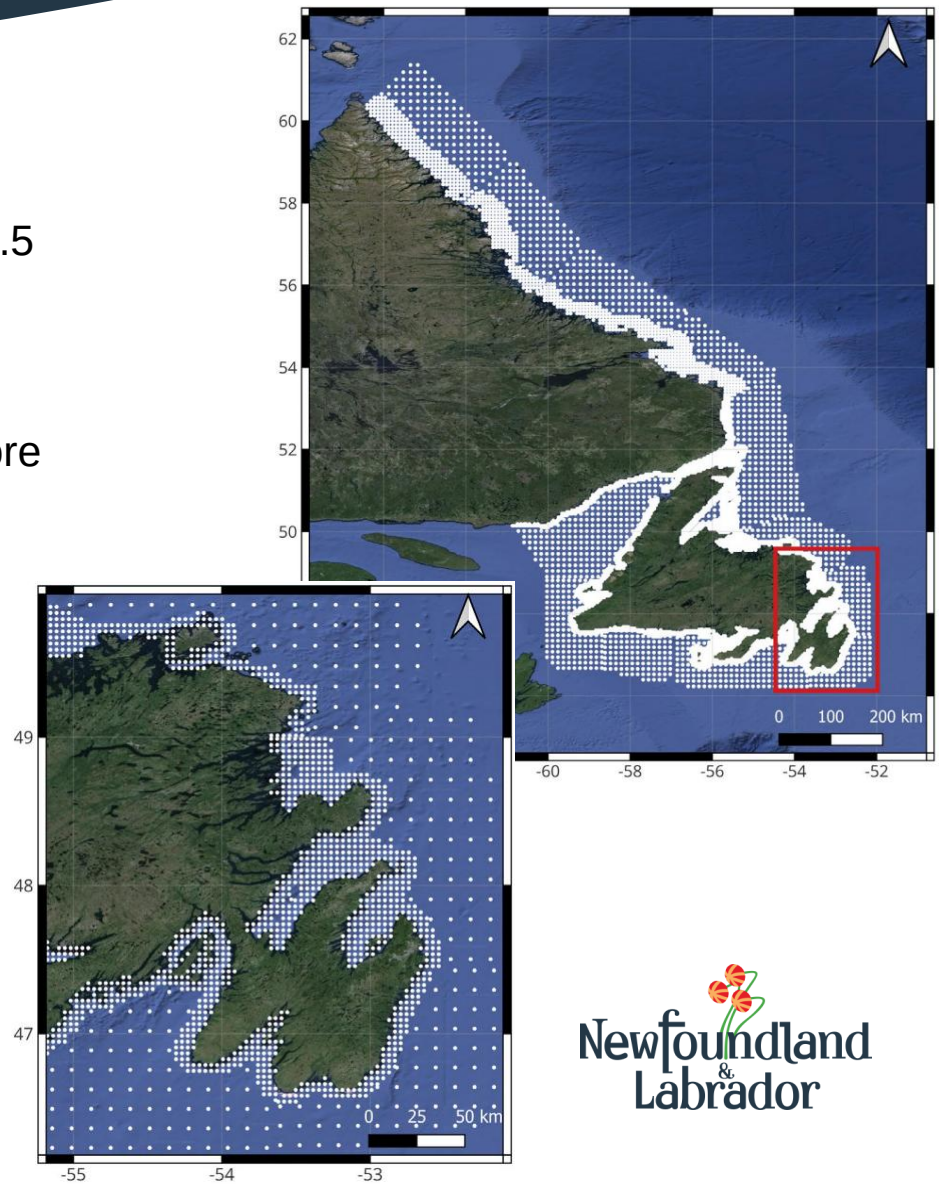
Atlas Development – Model Validation

- Model outputs were validated with observed values from water level stations and wave buoys
- Good agreement with buoy data:
  - Significant wave height and direction well-modelled
  - Direction distribution well captured
  - Peak period more variable
  - Strong comparisons vs MSC50 & ERA5

Newfoundland & Labrador

Atlas Deliverables – Timeseries

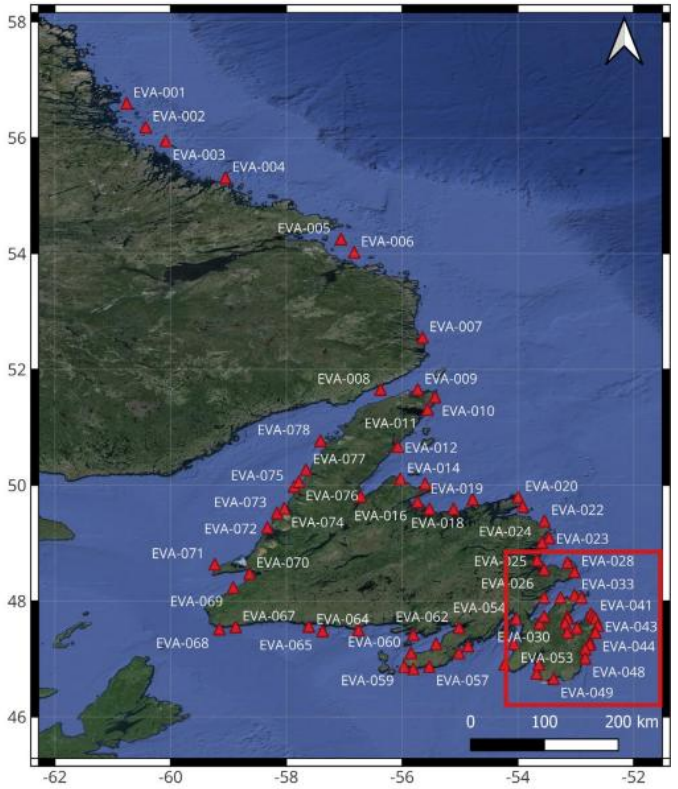
- Regional modelling of storm surge and waves
  - High resolution modelling using spatial resolutions as fine as 1.5 km
  - Validated against measurements at various points around the province
  - Output points ranging from ~10 km offshore to ~ 3 km nearshore
- Timeseries datasets produced for 5830 output points
- Hourly Hindcast datasets from 1980-2022 and 3-hourly forecast datasets from 2015-2100:
  - Significant Wave Height (m)
  - Peak Wave Period (s)
  - Mean Wave Direction (degN from)
  - Storm Surge (m)
  - Ice Concentration

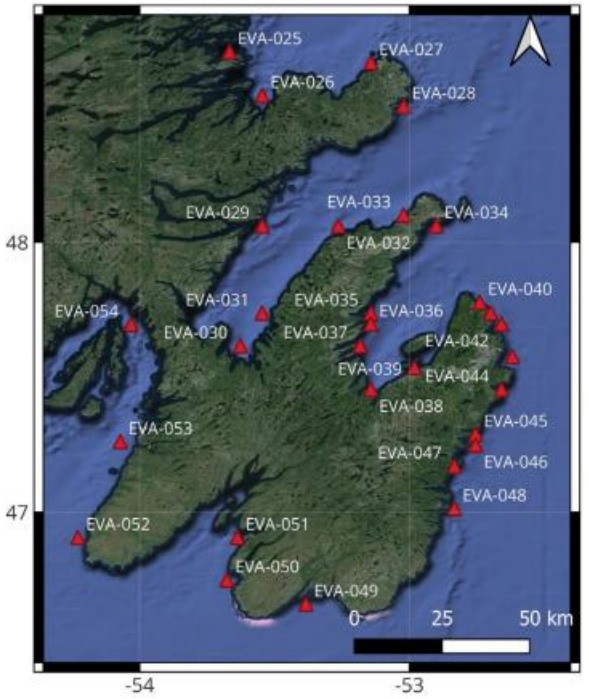


Newfoundland & Labrador

Atlas Deliverables – Extreme Value Analysis

- EVA statistics produced for 78 points:
- 1:2, 1:5, 1:10, 1:20, 1:50, 1:100-year return periods:
  - Storm surge
  - Omnidirectional Wave Heights
  - Directional Wave height (45° increments)
  - Wave peak period for 5th, 50th, 95th percentiles



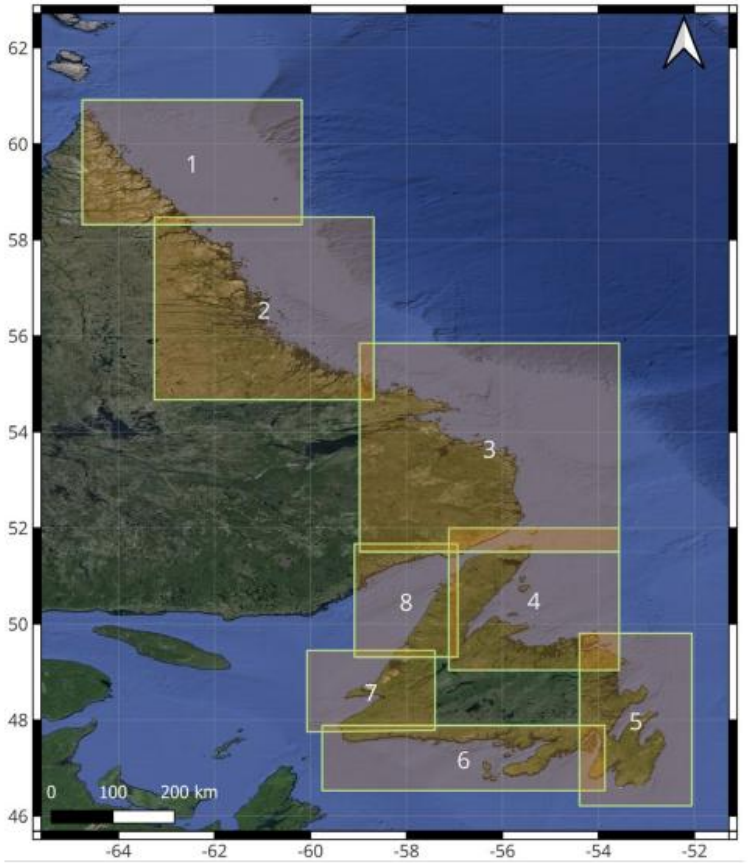


Newfoundland & Labrador

Atlas Deliverables – Statistical Maps

Hindcast and forecast maps:

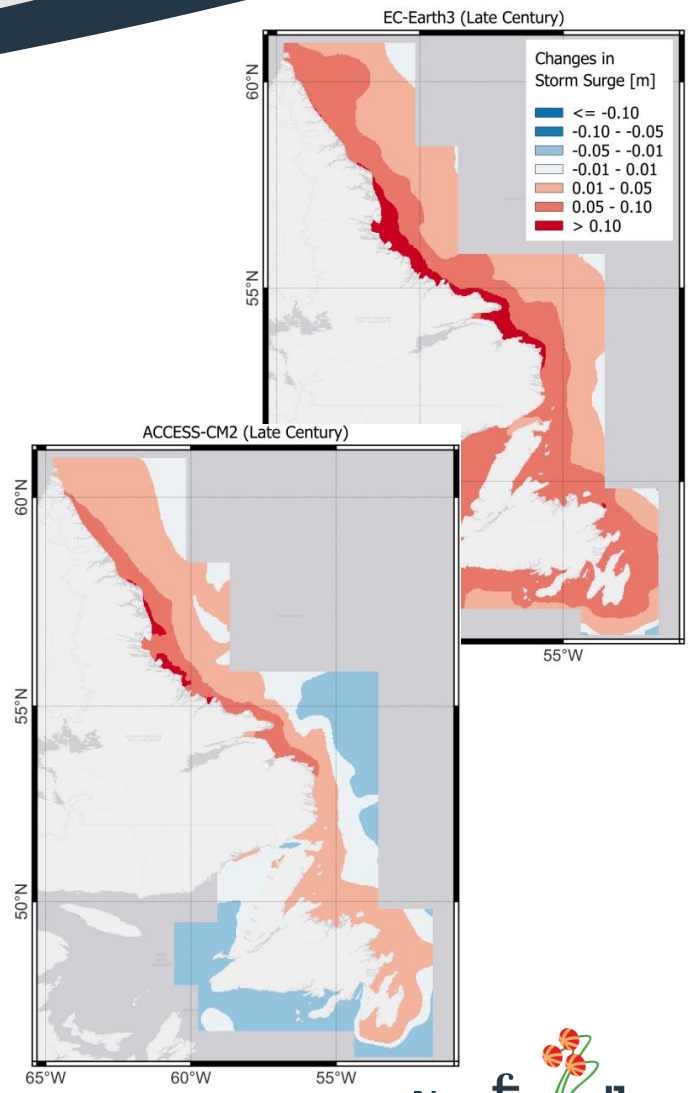
- Data points of interest:
  - 5830
  - 78
- Hindcast maps (50th and 99th percentile and Average Annual Maximum values):
  - Significant Wave Height of Total Wave Spectrum
  - Storm Surge
- Forecast maps (50th and 99th percentile and Average Annual Maximum values):
  - Changes in Significant Wave Height of Total Wave Spectrum
  - Changes in Storm Surge



Newfoundland & Labrador

Atlas Development – Climate Change Assessment

- Forecast data driven by two Global Climate Models (GCM) from the Coupled Model Intercomparison Project (Phase 6) (or CMIP6):
  - EC-EARTH3 SSP5-8.5
  - ACCESS-CM2 SSP5-8.5
  - Both GCM's used the Shared Socioeconomic Pathway 5-8.5 scenario (SSP5-8.5)
- Models consistently forecast an elevation in wave conditions and surge levels along the Labrador coast due to reduced ice cover
- The simulations of the two GCMs indicate less pronounced trends across the studied area
- Multi-model ensemble approach allows for the capturing of inherent variability in climate change scenarios



Newfoundland & Labrador

Limitations/Next Steps

- Wave effects (wave set-up), non-linear tide-surge and local processes were not accounted for in the models
- Hurricanes in ERA5 scenario were under-represented
- Local features not resolved:
  - Harbour geometry
  - Coastal defenses
  - Small-scale bathymetry
- Next steps:
  - Complete EVA for 1:200-year return period
  - Include more GCM's for a more robust multi-model climate change assessment

Shoreline Armouring at Long Pond

Conception Bay South, NL

Newfoundland & Labrador

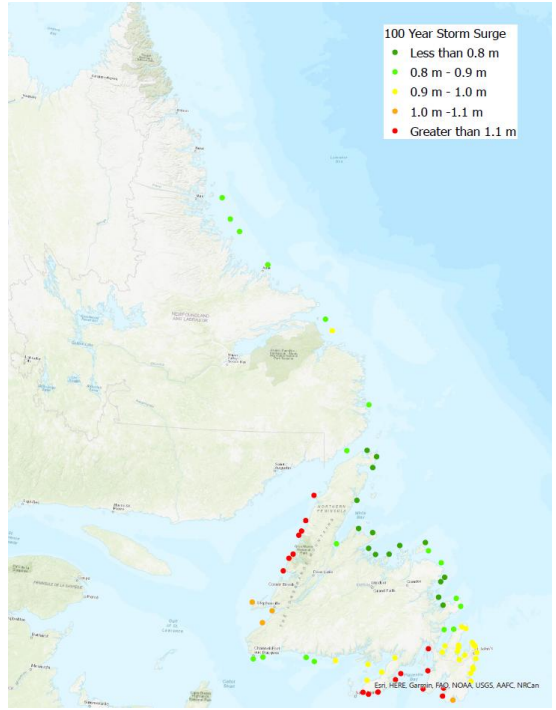
Uses of the Atlas

High level technical dataset

The Atlas datasets can be used at a regional and local level

- Regional planning and high-level vulnerability assessments
  - Supports strategic coastal planning
  - Allows for more detailed simulations and localized modeling for specific regions
  - Assessment of risks due to future climate conditions to inform long-term adaptation strategies

- General public information and understanding
  - Information and data from the Atlas can be used for outreach (workshops, campaigns, forums, etc.)
  - Helps bring awareness to coastal risks to encourage informed resilient communities

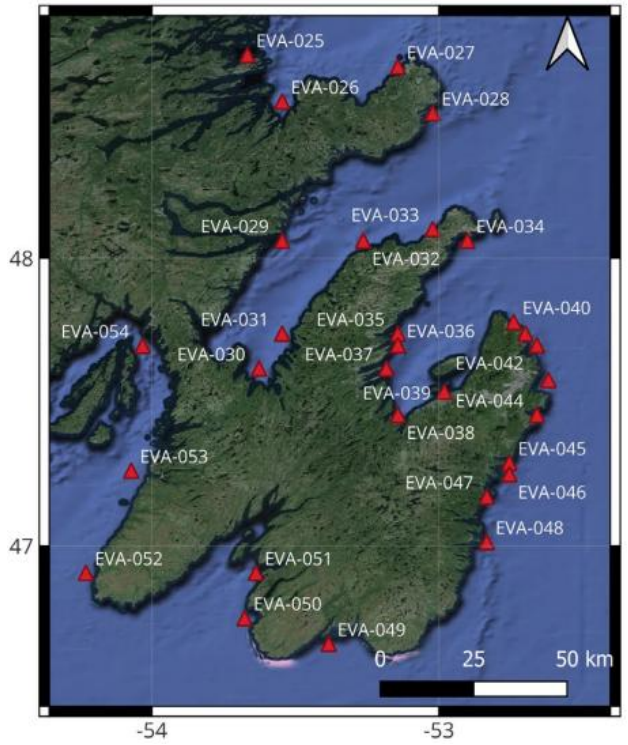


Newfoundland & Labrador

Uses of the Atlas

- Boundary conditions and data for:
  - Site-specific numerical modeling, using local bathymetry and shoreline information
  - River hydraulic models for riverine flooding
  - Downscaled community level storm surge and wave modelling

- Other uses include:
  - Determining AEP of recent extreme storm surge events
  - Preliminary design and assessment of coastal infrastructure projects
  - EVA of the other 5752 output points for location specific purposes



Newfoundland & Labrador

Uses of the Atlas – Data Request

Some data requests that we've received include:

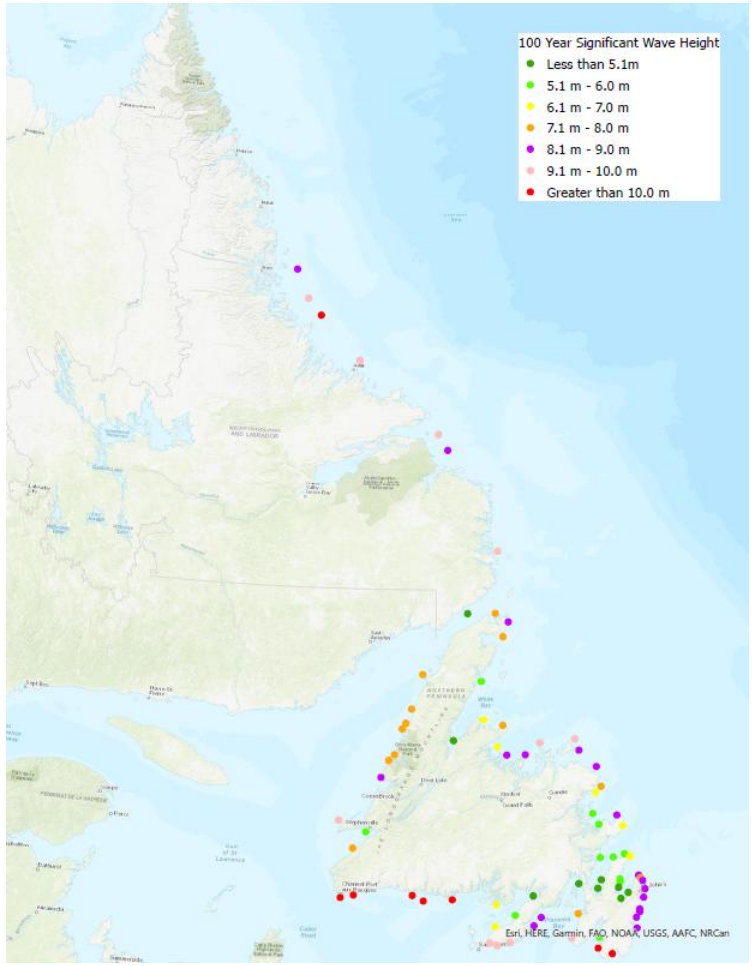
- Assessment of wave heights and storm surge statistics for the St. John's Harbour (EVA Points and hindcast timeseries data)
- Feasibility study for a potential port development in Labrador (EVA points and hindcast and climate change timeseries data)
- Feasibility studies for climate adaption measures in several coastal communities in Newfoundland and Labrador (hindcast and climate change timeseries data)
- MUN research on the most salt tolerant plants to incorporate into nature-based solutions to combat coastal erosion in NL (EVA Points)

Beach Pea

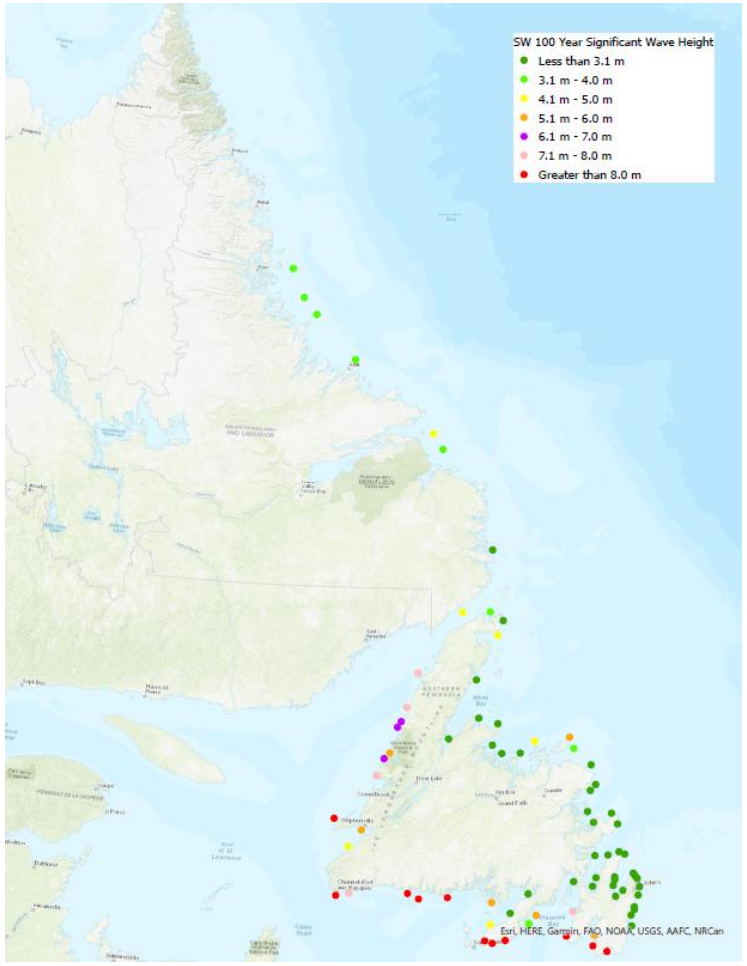
Newfoundland & Labrador

Coastal Areas of NL Vulnerable to Waves

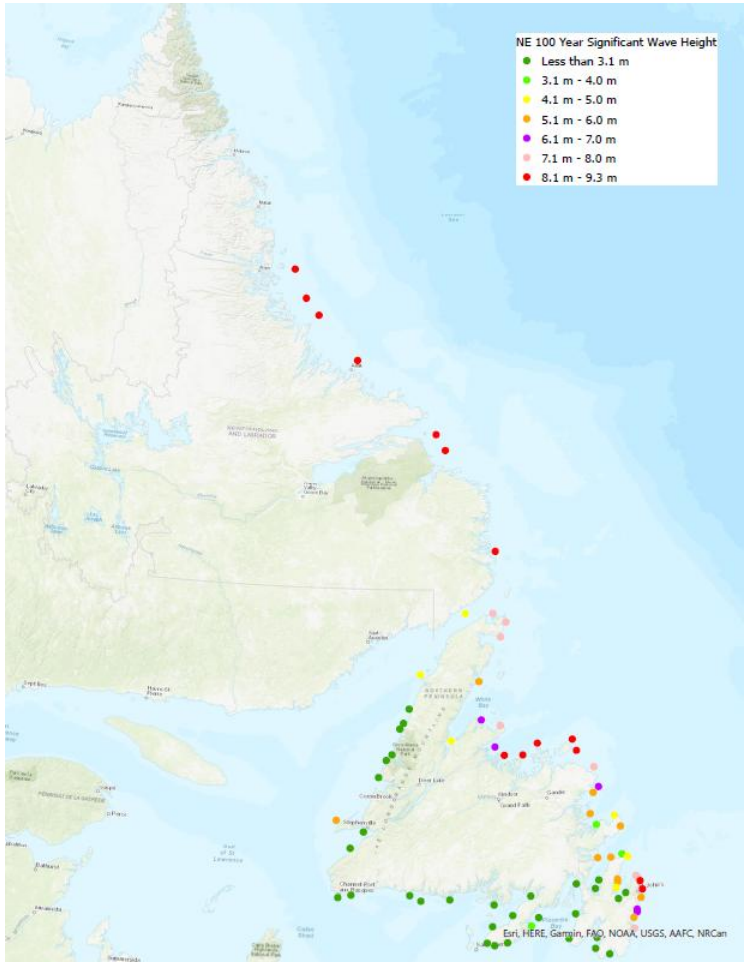
Omnidirectional



Southwest

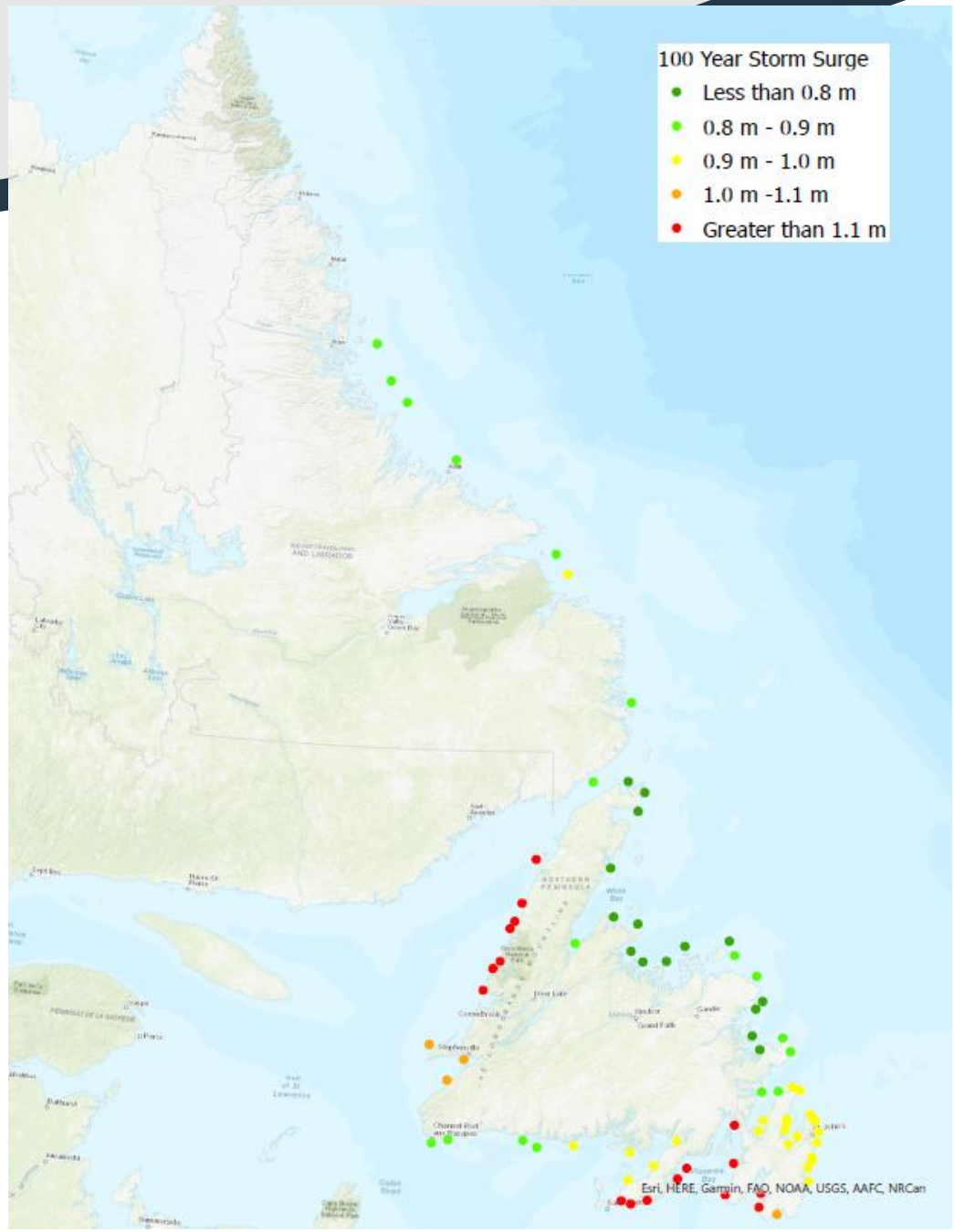


Northeast



Coastal Areas of NL Vulnerable to Storm Surge

- Exposed communities typically have development at higher elevation
- More sheltered communities have development right at sea level making them even more vulnerable to surge events (e.g., Conception Bay)

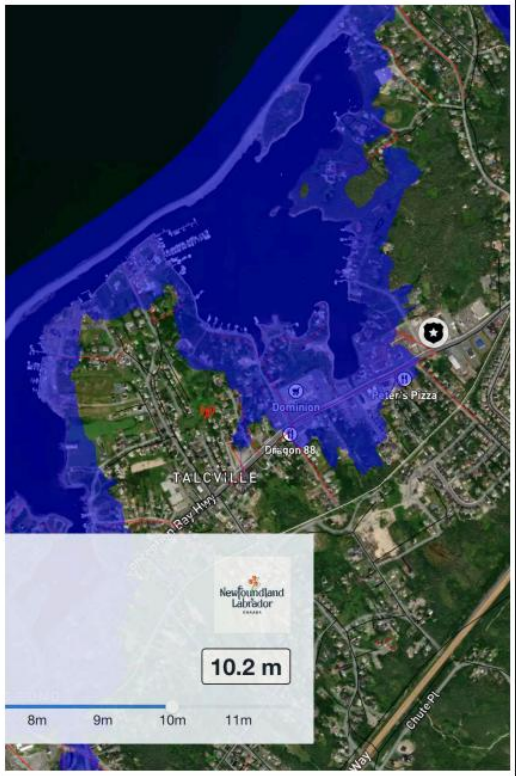


Newfoundland & Labrador

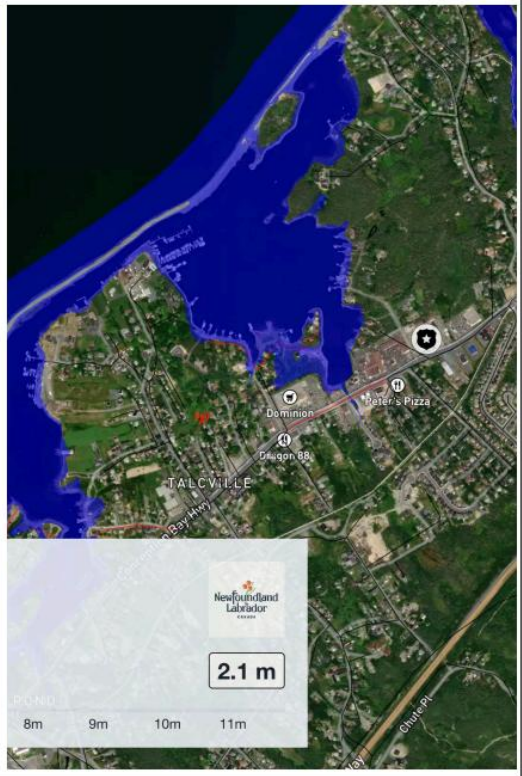
Coastal Flood Simulation App

NL Coastal Flood Simulation App Background

- Developed for the WRMD by C-Core
- Helps users visualize coastal flood scenarios across Newfoundland
- Web-based tool using high-resolution LiDAR elevation data
- Simulates flooding at 10 cm intervals up to 12 m above sea level
- Uses the CGVD2013 vertical datum
- Supports planning for storm surge impacts and rising sea levels



A 10.2 m simulated flood

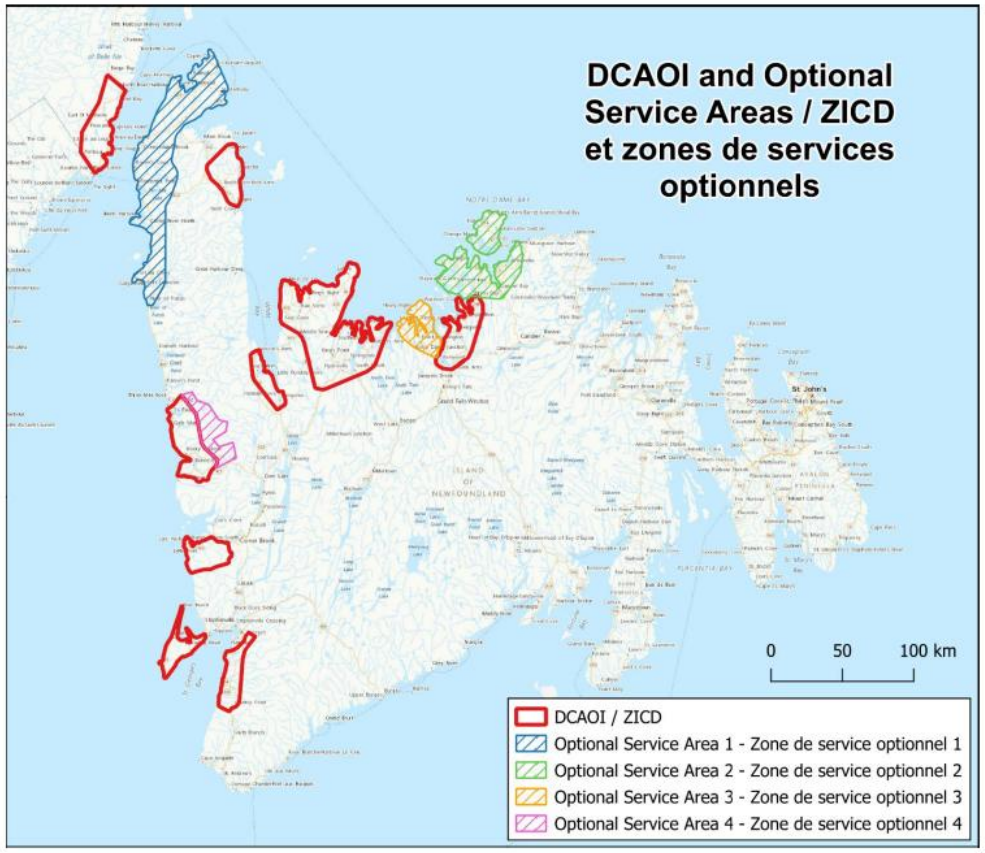


A 2.1 m simulated flood

Newfoundland & Labrador

NL Coastal Flood Simulation App Background – LiDAR and HRDEM

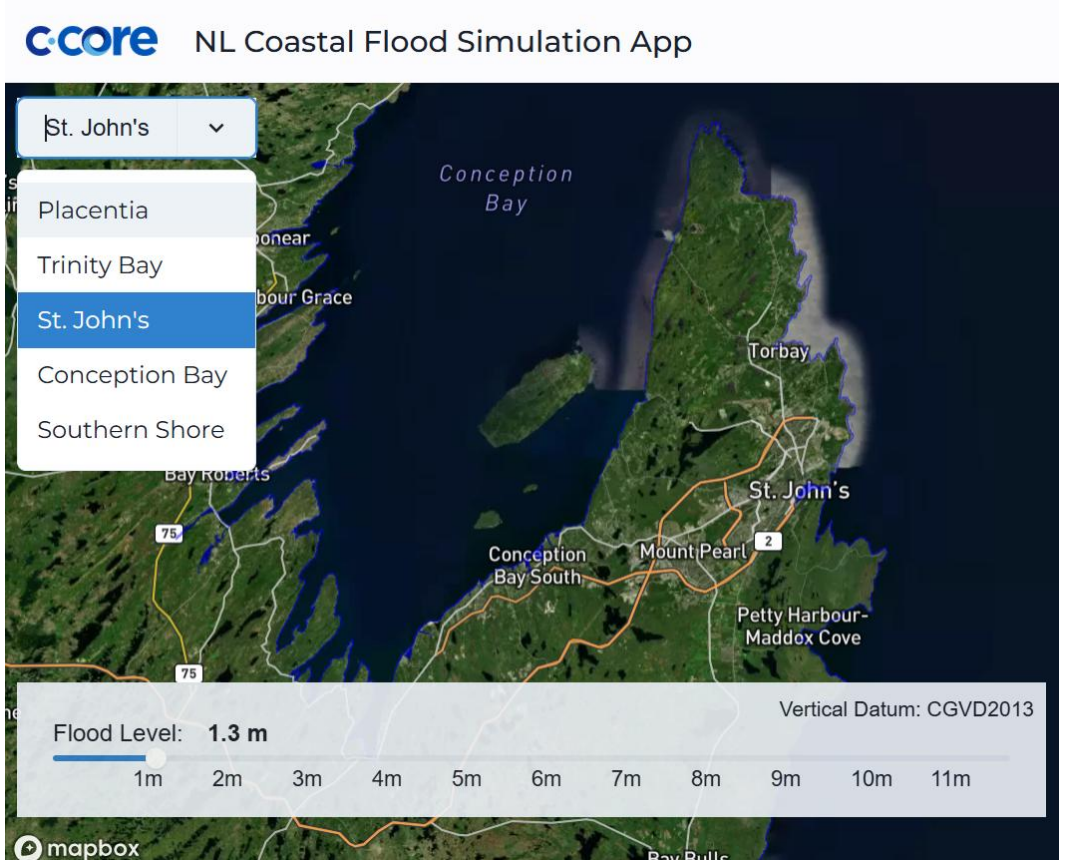
- LiDAR or light detection and ranging uses a sensor, typically mounted on an aircraft, to send out laser pulses, measuring the time for those pulses to return
- Based on the return time a High-Resolution Digital Elevation Model or HRDEM can be created which provides a detailed 3D model of the grounds surface
- The non red outlines display the areas where LiDAR was collected this year
- WRMD will continue to collect more LiDAR for the province over the coming years
- All LiDAR is available from NRCan here: https://open.canada.ca/data/en/dataset/957782bf-847c-4644-a757-e383c0057995



Newfoundland & Labrador

NL Coastal Flood Simulation App Background

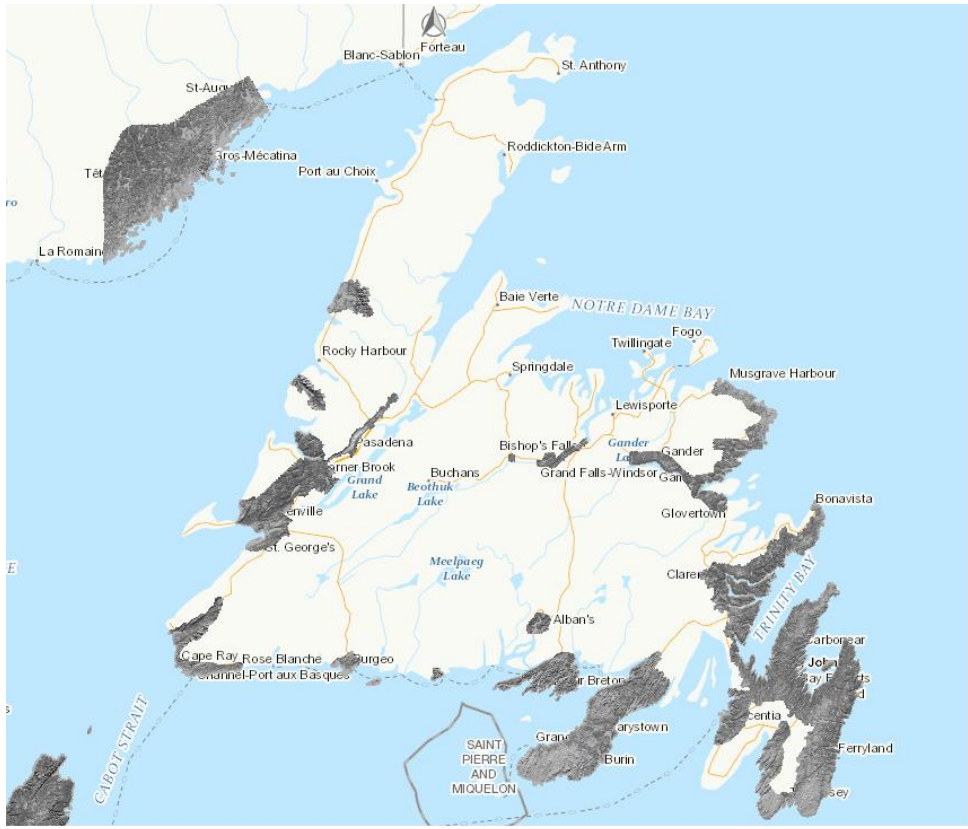
- Uses a bathtub model with hydraulic connectivity to ensure realistic flood spread
- Generates flood depths and extents dynamically across the coastline
- Includes overlays for:
  - Critical infrastructure
  - Road networks
  - Active tide gauge locations
- Helps identify areas most at risk and assets exposed to flooding
- LiDAR data has been collected for five areas on Avalon Peninsula
- As additional coastal LiDAR is collected, more locations will be added to the App



Newfoundland & Labrador

Limitations/Next Steps

- Limitations:
  - Not all hydraulic connectivity may be included (missed culverts, etc.)
  - Differences in datums (water elevations have to be converted)
- Next steps:
  - Adding more areas to the app as more LiDAR is acquired
  - West coast data blocks should be added by end of fiscal year



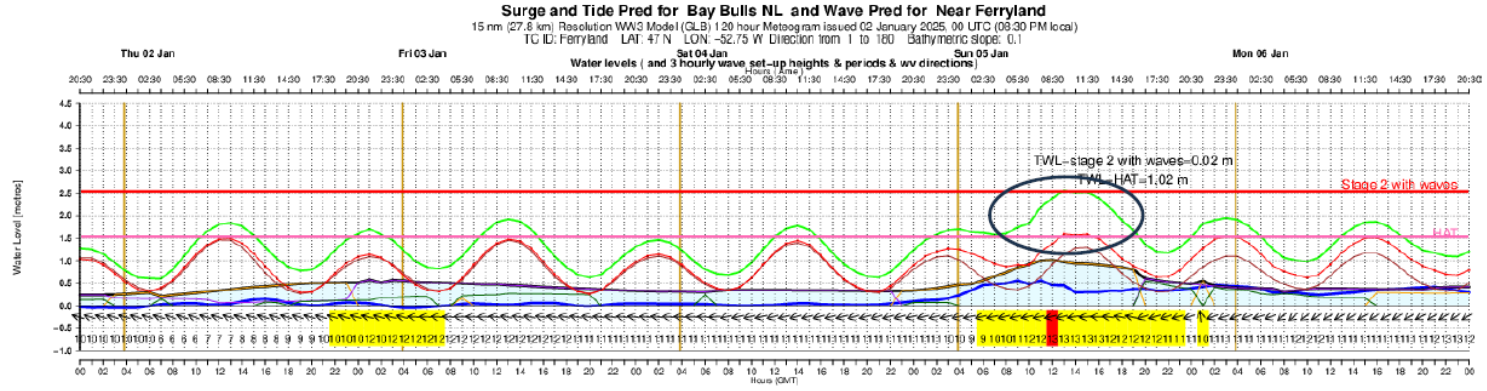
Newfoundland & Labrador

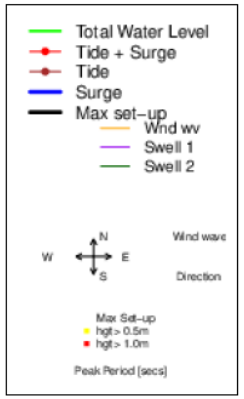
Newfoundland & Labrador

Demonstration

NL Coastal Flood Simulation App
Use Case

POSSIBLE WATER LEVELS: EAST COAST (IMAGE BELOW FOR BAY BULLS/FERRYLAND)





Higher than normal water levels, high waves and pounding surf are expected for parts of the east coast of Newfoundland, from the Southern Shore to Bonavista Bay.

Water levels will likely exceed High Astronomical Tide (pink line) during this time frame, with highest water levels (near Stage 2 flooding line) likely near high tide Sunday morning, with a second lower peak near high tide Sunday night.

Currently low to moderate probability of flooding over low-lying coastal areas. Areas at highest risk would be low-lying areas exposed to the east or northeast.

This will continue to be monitored over the coming days.

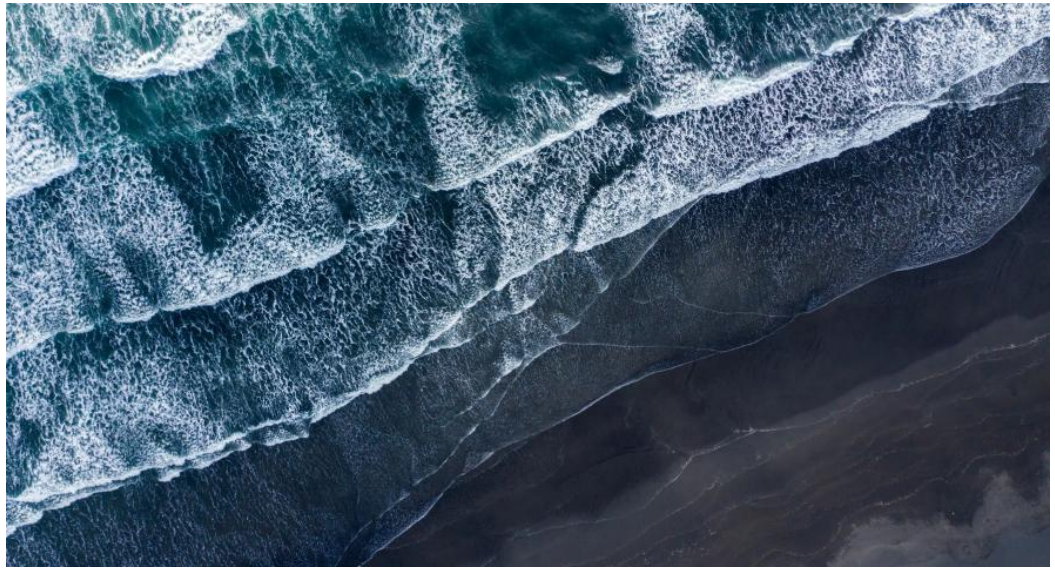
Newfoundland & Labrador

NL Coastal Flood Simulation App Use Case

Newfoundland & Labrador

Conclusion

- As climate change affects the environment around us, it is important to identify and mitigate flood risks in coastal communities
- The Atlas and Flood Simulation App are both valuable tools for understanding and mitigating flood risks in coastal communities throughout Newfoundland and Labrador
- We encourage the use of both tools to inform planning and decision making in these coastal communities



Newfoundland & Labrador

NL Atlas of Storm Surge and Wave Climates - Key Resources

Atlas:

https://www.gov.nl.ca/eccc/files/NL_Atlas_StormSurge_Waves_Documentation_Finalv1.1_Signed.pdf

Menu of datasets and statistical analyses produced from the Atlas:

https://www.gov.nl.ca/eccc/files/NL_Atlas_Deliverables_Contents.pdf

Flood Risk Mapping Studies:

https://www.gov.nl.ca/eccc/waterres/flooding/frm/

NL Coastal Flood Simulation App:

https://www.nlfloodsimulation.ca/demo/vas/nl-flood-modelling

Newfoundland & Labrador

WRMD Contacts

Ethan Slaney: ethanslaney@gov.nl.ca

Paula Dawe: pauladawe@gov.nl.ca

Newfoundland & Labrador

Questions?

Newfoundland & Labrador

Dataset Menu

Run	Item	Description	Location	Files
Climate Change - Historical Baseline (1984-2014) and Future Projections (2015-2100)	Timeseries	3-hourly time series of storm surge and wave bulk parameters for a historical baseline (period of 1984-2014) and for the SSP5-8.5 climate change scenario (period of 2015-2100) forced by two Global Climate Models (EC-EARTH3 and ACCESS-CM2). Variables: - Hm0_Total: Significant Wave Height of Total Wave spectrum (m) - Tp_Total: Peak Period of Total Wave Spectrum (s) - MWD_Total: Mean Direction of Total Wave Spectrum (degN from) - WL_Res: Residual Water Level - Storm Surge (m) - Ice_Conc: Ice Concentration	5.830 high density output points along the NL coast and offshore	Results provided as .csv files: ACCESS-CM2 BASELINE: ./NL_ATLAS_TIMESERIES/NL_ATLAS_TIMESERIES_ACCESS_CM2_HISTORICAL_BASELINE.zip EC-EARTH3 BASELINE: ./NL_ATLAS_TIMESERIES/NL_ATLAS_TIMESERIES_EC-EARTH3_HISTORICAL_BASELINE.zip ACCESS-CM2 SSP5-8.5: ./NL_ATLAS_TIMESERIES/NL_ATLAS_TIMESERIES_ACCESS_CM2_SSP585.zip EC-EARTH3 SSP5-8.5: ./NL_ATLAS_TIMESERIES/NL_ATLAS_TIMESERIES_EC-EARTH3_SSP585.zip Output points coordinates: ./NL_ATLAS_TIMESERIES/NL_ATLAS_OUTPUT_POINTS_shapefile.zip
	Statistical Maps	Maps of projected changes in Significant Wave Height of Total Wave Spectrum (m) statistics relative to the historical baseline for mid- and late-century, considering the SSP5-8.5 climate change scenario and two Global Climate Models (EC-EARTH and ACCESS-CM2). Variables (Full Name / Short Name): - Hm0_Total Mid-Century 50th Percentile Difference (SSP5-8.5 ACCESS-CM2) / dHm0_MC_50p_AC2 - Hm0_Total Mid-Century 99th Percentile Difference (SSP5-8.5 ACCESS-CM2) / dHm0_MC_99p_AC2 - Hm0_Total Mid-Century Avg Annual Max Difference (SSP5-8.5 ACCESS-CM2) / dHm0_MC_AAM_AC2 - Hm0_Total Late-Century 50th Percentile Difference (SSP5-8.5 ACCESS-CM2) / dHm0_LC_50p_AC2 - Hm0_Total Late-Century 99th Percentile Difference (SSP5-8.5 ACCESS-CM2) / dHm0_LC_99p_AC2 - Hm0_Total Late-Century Avg Annual Max Difference (SSP5-8.5 ACCESS-CM2) / dHm0_LC_AAM_AC2 - Hm0_Total Mid-Century 50th Percentile Difference (SSP5-8.5 EC-EARTH3) / dHm0_MC_50p_EC3 - Hm0_Total Mid-Century 99th Percentile Difference (SSP5-8.5 EC-EARTH3) / dHm0_MC_99p_EC3 - Hm0_Total Mid-Century Avg Annual Max Difference (SSP5-8.5 EC-EARTH3) / dHm0_MC_AAM_EC3 - Hm0_Total Late-Century 50th Percentile Difference (SSP5-8.5 EC-EARTH3) / dHm0_LC_50p_EC3 - Hm0_Total Late-Century 99th Percentile Difference (SSP5-8.5 EC-EARTH3) / dHm0_LC_99p_EC3 - Hm0_Total Late-Century Avg Annual Max Difference (SSP5-8.5 EC-EARTH3) / dHm0_LC_AAM_EC3	5.830 high density output points along the NL coast and offshore. Statistical results are divided into 12 areas corresponding to the wave model subdomains.	Results provided as .csv and GeoJSON: Hm0 STATISTICS CC PROJECTION CHANGES: /NL_ATLAS_STATISTICS/Hm0_CC_PROJECTIONS.zip Output points: /NL_ATLAS_TIMESERIES/NL_ATLAS_OUTPUT_POINTS_shapefile.zip
		Maps of projected changes in Storm Surge Residual Water Level (m) statistics relative to the historical baseline for mid- and late-century, considering the SSP5-8.5 climate change scenario and two Global Climate Models (EC-EARTH and ACCESS-CM2). Variables: - WL_Res Mid-Century 50th Percentile Difference (SSP5-8.5 ACCESS-CM2) - WL_Res Mid-Century 99th Percentile Difference (SSP5-8.5 ACCESS-CM2) - WL_Res Mid-Century Avg Annual Max Difference (SSP5-8.5 ACCESS-CM2) - WL_Res Late-Century 50th Percentile Difference (SSP5-8.5 ACCESS-CM2) - WL_Res Late-Century 99th Percentile Difference (SSP5-8.5 ACCESS-CM2) - WL_Res Late-Century Avg Annual Max Difference (SSP5-8.5 ACCESS-CM2) - WL_Res Mid-Century 50th Percentile Difference (SSP5-8.5 EC-EARTH3) - WL_Res Mid-Century 99th Percentile Difference (SSP5-8.5 EC-EARTH3) - WL_Res Mid-Century Avg Annual Max Difference (SSP5-8.5 EC-EARTH3) - WL_Res Late-Century 50th Percentile Difference (SSP5-8.5 EC-EARTH3) - WL_Res Late-Century 99th Percentile Difference (SSP5-8.5 EC-EARTH3) - WL_Res Late-Century Avg Annual Max Difference (SSP5-8.5 EC-EARTH3)	Raster maps along the NL coast and offshore. Statistical climate change maps are divided into 8 raster tiles.	Results provided as raster files: WL STATISTICS CC PROJECTION CHANGES: /NL_ATLAS_STATISTICS/WL_Res_STATS_CC_PROJECTIONS.zip Raster Maps Limits: /NL_ATLAS_STATISTICS/WL_Res_STATS_Raster_Domains_shapefile.zip

Run	Item	Description	Location	Files
Hindcast (1980-2022)	Timeseries	Hourly time series of storm surge and waves hindcast for the period 1980 to 2022 Variables: - Hm0_Total: Significant Wave Height of Total Wave Spectrum (m) - Tp_Total: Peak Period of Total Wave Spectrum (s) - MWD_Total: Mean Direction of Total Wave Spectrum (degN from) - WL_Res: Residual Water Level - Storm Surge (m) - Ice_Conc: Ice Concentration	5.830 high density output points along the NL coast and offshore	Results provided as .csv files: Timeseries: /NL_ATLAS_TIMESERIES/NL_ATLAS_TIMESERIES_HINDCAST.zip Output points coordinates: /NL_ATLAS_TIMESERIES/NL_ATLAS_OUTPUT_POINTS_shapefile.zip
	Extreme Value Analysis	Extreme Significant Wave Height of Total Wave Spectrum (Hm0) - Omnidirectional for 1, 2, 5, 10, 25, 50, 100-year return periods - Directional (30° bins) for 1, 2, 5, 10, 25, 50, 100-year return periods Associated Extreme Peak Period of Total Wave Spectrum (Tp) - 5th percentile of wave peak period associated with extreme Hm0 - 50th percentile of wave peak period associated with extreme Hm0 - 95th percentile of wave peak period associated with extreme Hm0 Extreme Residual Water Level - Storm Surge (WL_Res) - For 1, 2, 5, 10, 25, 50, 100-year return periods	78 analysis points near key NL coastal communities.	Results provided as .csv and GeoJSON: EVA output files: ./NL_ATLAS_EVA/NL_ATLAS_EVA.zip EVA output points coordinates: ./NL_ATLAS_EVA/NL_ATLAS_EVA_Analysis_Points_shapefile.zip
	Statistical Maps	Maps of Significant Wave Height of Total Wave Spectrum (m) statistics for the Hindcast run (1980-2022) Variables (full name / short name): - Hm0_Total 50th Percentile / Hm0_50p - Hm0_Total 99th Percentile / Hm0_99p - Hm0_Total Average Annual Maximum / Hm0_AAM	5.830 high density output points along the NL coast and offshore. Statistical results are divided into 12 areas corresponding to the wave model subdomains.	Results provided as .csv and GeoJSON: Statistical maps csvs and shapefiles: /NL_ATLAS_STATISTICS/Hm0_STATS_HINDCAST.zip Output points: /NL_ATLAS_TIMESERIES/NL_ATLAS_OUTPUT_POINTS_shapefile.zip
		Maps of Residual Water Level - Storm Surge (m) statistics for the Hindcast run (1980-2022) Variables: - WL_Res 50th Percentile - WL_Res 99th Percentile - WL_Res Average Annual Maximum	Raster maps along the NL coast and offshore. Statistical maps are divided into 8 raster tiles.	Results provided as raster files: Statistical maps raster files: /NL_ATLAS_STATISTICS/WL_Res_STATS_HINDCAST.zip Raster maps limits: /NL_ATLAS_STATISTICS/WL_Res_STATS_Raster_Domains_shapefile.zip

Newfoundland & Labrador