

Predicting and Alerting for Coastal Flooding

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Environment and Climate Change Canada's 50th anniversary
50^e anniversaire d'Environnement et Changement climatique Canada

Meteorological Service of Canada's 150th anniversary
150^e anniversaire du Service météorologique du Canada



Environment and
Climate Change Canada

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Changement climatique Canada

Canada

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Outline

- Why are we doing this?
- What did we say we were going to do?
- How are we going to do this?
- Opportunities for improvement

What did we say we were going to do?



2019 Emergency Management Strategy for Canada

Coastal Flooding Alerts 5-Day Coastal Flooding Risk Outlook

- “This initiative will invest in developing **comprehensive coastal flooding prediction and alerting services, expanding on the existing program for the Atlantic, to the remaining basins (Great Lakes, Saint Lawrence, Pacific and Arctic coasts)** to support public safety, resilient coastal communities and safer near-shore marine navigation.”
- “The capability to **deliver 24/7 coastal water level alerting capacity** to the Pacific and Arctic marine waters and the Great Lakes and St. Lawrence will be developed.”
- “This project will introduce new modelling and visualisation innovations and **include uncertainties** associated with water level predictions above and beyond the qualitative storm surge forecasts currently produced for the Atlantic Coast.”
- “The objective is to provide maps that articulate the **probability and risk** of coastal flooding **out to 5 days** to provide early notification to the emergency management community of impending events and their likelihood.”

Building Resiliency Together

Emergency Management Strategy for Canada

Toward a Resilient 2030

Federal/Provincial/Territorial Emergency Management Partners

Canada Ontario Quebec NOVA SCOTIA NEWVILLE SCOTIA BRUNSWICK Manitoba BRITISH COLUMBIA Prince Edward Island Saskatchewan Alberta Newfoundland and Labrador Yukon Northwest Territories

How are we going to do this?



Common Vertical Datum and language; Coastal flooding Hazard, Vulnerability and Impacts

- Coastal Flooding

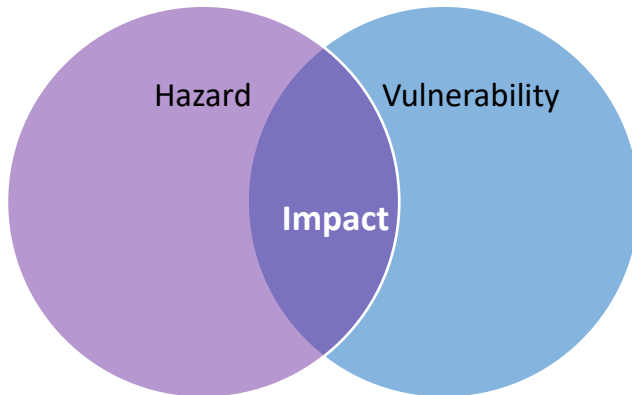
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Some volume/level of water incident along the coast.

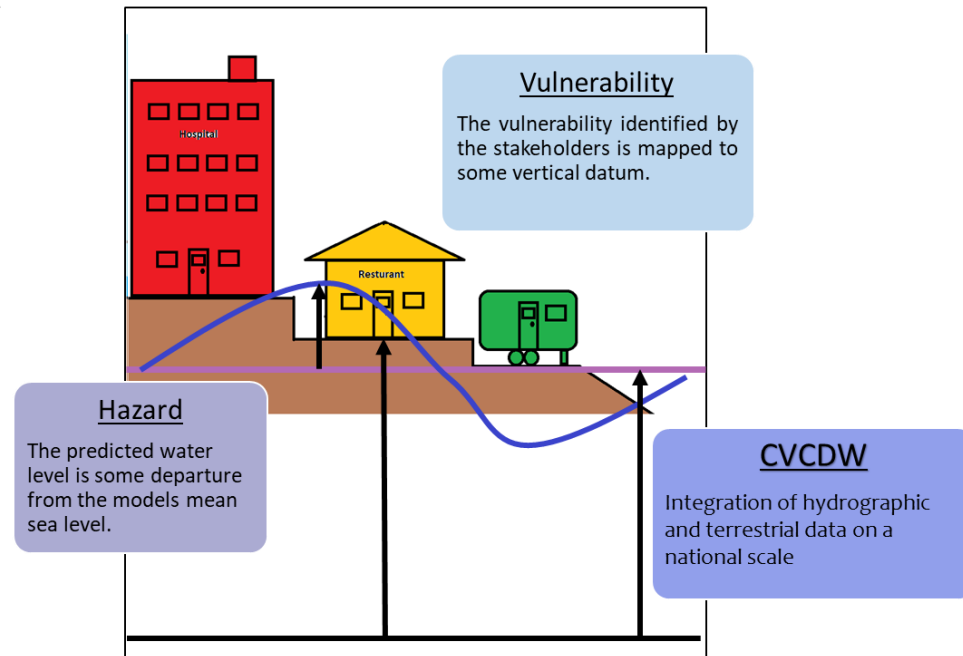
Impact:

Vulnerability:

Dependent on what that volume/level of water comes in contact with.



Vertical Challenge



How are we going to do this?



Coastal Flooding Impact Tiers

- We've Narrowed the scope of coastal flooding 'Impact' to the short term:
 - Damage to infrastructure or property
 - Disruption to travel
 - Danger to life

- PACF is NOT at this time trying to forecast the impacts from:
 - Erosion
 - Deterioration of health conditions from waterborne diseases.
 - Socio, economic and psychologic impacts on individuals or communities from:
 - disruption to industry
 - loss of infrastructure
 - displacement of people
 - loss of livelihoods
 - reduction in purchasing power and loss of land value in the floodplains that can leave communities economically vulnerable.

• Coastal Flooding

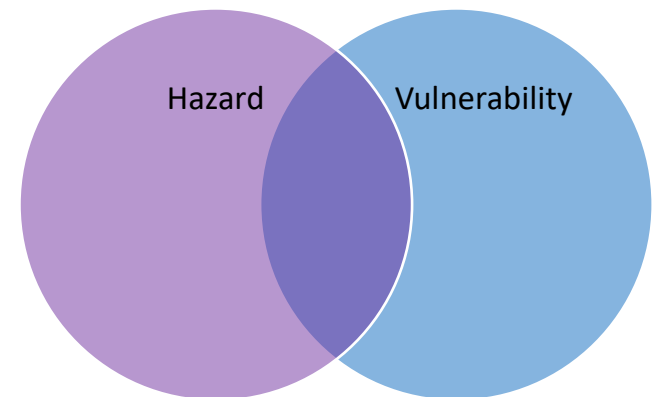
Hazard:

Some volume/level of water incident along the coast.

Impact:

Vulnerability:

Dependent on what that volume/level of water comes in contact with.



How are we going to do this?



Coastal Flooding Impact Tiers

- At this time, capabilities are being developed under PACF to forecast:
 - Tides
 - Storm Surge
 - Increase of water at the shoreline level due to incident waves
- ECCC is NOT developing the capacity to forecast flooding due to:
 1. Tsunami: waves caused by the displacement of a large volume of water (earth quake, landslide, etc.).
 2. Flash floods: an excessive amount of rain in a short period of time.
 3. River floods: when water levels run over river banks, as a result of heavy rain or snow melt.
- We do recognize the water dynamics that occur at the mouth of rivers and will work with River Forecasting Centers to support their alerting programs.

Coastal Flooding

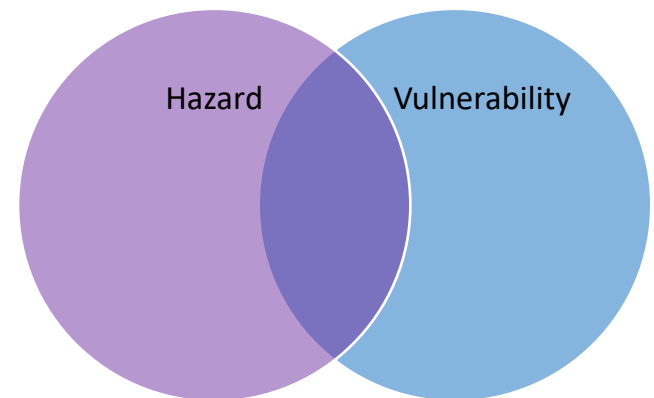
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Impact:

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How are we going to do this?



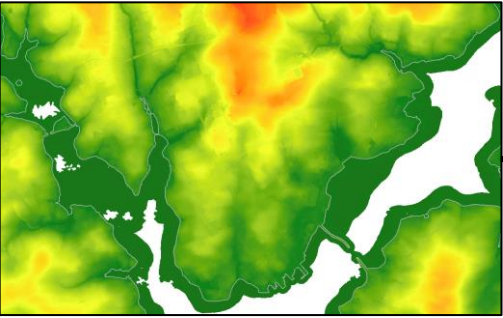
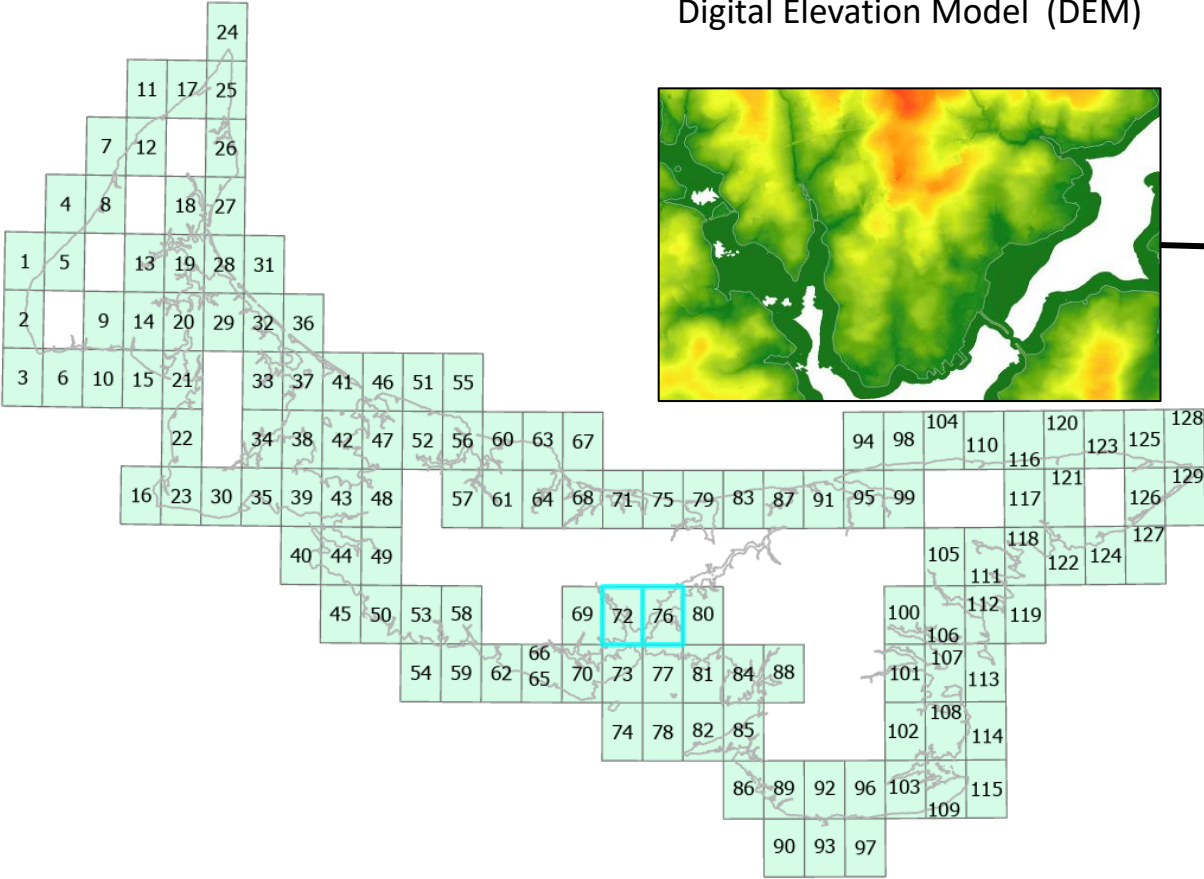
Common Vertical Datum and language; Coastal flooding Hazard, Vulnerability and Impacts

Proposed Wave Level	Level/ tier/ Category	Possible Disruption Time	Impact		Suggested Response (Call to Action)
			Receptor	Possible Consequence	
<HAT and no infrastructure	Null	NA	NA	none expected	NA
>HAT or beach roads, boat launch ramps, wharves	Minimal	Minutes to hours	Damage to infrastructure or property	inconvenience or nuisance flooding	personal property in low lying areas needs to be moved or it may get wet
			Disruption to travel	inconvenience or nuisance flooding	be aware of possibly wet nearshore roads
			Danger to life	individuals close to the coast maybe caught off guard by the rapid approach of unexpectedly larger waves or stronger currents	be aware of higher than usual water levels, waves or stronger currents
lowest infrastructure or seasonal road, cottage access road/driveway, wharf roads and buildings	Minor	Hours to days	Damage to infrastructure or property	water over banks and in yards or in campgrounds	personal property in low lying areas needs to be moved or may get damaged or destroyed
				damage to wharfs, boat houses and fishing stages. No significant flooding to main floors of residential buildings. Individual properties in coastal locations affected by spray and/or wave overtopping or slightly flooded basements or sewage backup	
			Disruption to travel	little or no disruption to travel although wet road surfaces could lead to difficult driving conditions water on bike paths	be prepared for possible longer journey times
			Danger to life	individuals close to the coast maybe caught off guard by the rapid approach of unexpectedly larger waves or stronger currents	be prepared for higher than usual water levels, waves or stronger currents
lowest infrastructure + 20-30 cm or houses; commercial or other public facilities (restaurant, museum, information centre)	Major	Days to months	Damage to infrastructure or property	Main floor flooding affecting properties and parts of communities Damage to buildings/structures is possible.	Disruption to key sites identified in flood plans (e.g. railways , utilities)
			Disruption to travel	Disruption to travel is expected. water over the road is deep enough to make driving unsafe	A number of roads should be closed.
			Danger to life	Possible danger to life due to fast flowing/deep water/wave overtopping/wave inundation.	Evacuation will be possible or access restricted for the most vulnerable shoreline and coastal areas.
lowest critical infrastructure or main roads (or access roads to multiple houses)	Severe	Months to years	Damage to infrastructure or property	Widespread flooding affecting significant number of properties and whole communities Collapse of building/structures is possible multiple homes are flooded or moved off foundations	Widespread disruption or loss of infrastructure identified in flood plans (e.g. railways, utilities, hospitals)
				Disruption to travel	
			Danger to life	Danger to life due to fast flowing / deep water / wave overtopping/ wave inundation	Large scale evacuation may be required

How are we going to do this?



Example: Current PACF Engagement with PEI



Contours at 10 cm increments



Lower limit: Mean sea level (MSL)
Upper Limit: 5 m
(2100 extreme storm surge scenario)

How are we going to do this?



Example: Current PACF Engagement with PEI

Proposed Wave Level	Level/ tier/ Category	Possible Disruption Time	Impact		Suggested Response (Call to Action)
			Receptor	Possible Consequence	
<HAT	negligible	NA	NA	none expected	NA
>HAT beach roads, boat launch ramps, wharves	Minimal	Minutes to hours	Damage to infrastructure or property	inconvenience or nuisance flooding	personal property in low lying areas needs to be moved or it may get wet
			Disruption to travel	inconvenience or nuisance flooding	be aware of possibly wet nearshore roads
			Danger to life	individuals close to the coast maybe caught off guard by the rapid approach of unexpectedly larger waves or stronger currents	be aware of higher than usual water levels, waves or stronger currents
lowest infrastructure or seasonal road, cottage access road/driveway, wharf roads and buildings	Minor	Hours to days	Damage to infrastructure or property	water over banks and in yards or in campgrounds damage to wharfs, boat houses and fishing stages. No significant flooding to main floors of residential buildings. Individual properties in coastal locations affected by spray and/or wave overtopping or slightly flooded basements or sewage backup	personal property in low lying areas needs to be moved or may get damaged or destroyed be prepared for the possibility of minor flooding of basements, elevate or relocate property to main floor be prepared for possible longer journey times
			Disruption to travel	little or no disruption to travel although wet road surfaces could lead to difficult driving conditions water on bike paths	
			Danger to life	individuals close to the coast maybe caught off guard by the rapid approach of unexpectedly larger waves or stronger currents	be prepared for higher than usual water levels, waves or stronger currents
lowest infrastructure + 20-30 cm or houses; commercial or other public facilities (restaurant, museum, information centre)	Significant / Major	Days to months	Damage to infrastructure or property	Main floor flooding affecting properties and parts of communities Damage to buildings/structures is possible.	Disruption to key sites identified in flood plans (e.g. railways, utilities)
			Disruption to travel	Disruption to travel is expected. water over the road is deep enough to make driving unsafe	A number of roads should be closed.
			Danger to life	Possible danger to life due to fast flowing/deep water/wave overtopping/wave inundation.	Evacuation will be possible or access restricted for the most vulnerable shoreline and coastal areas.
lowest critical infrastructure or main roads (or access roads to multiple houses)	Severe / Extreme / Critical	Months to years	Damage to infrastructure or property	Widespread flooding affecting significant number of properties and whole communities Collapse of building/structures is possible multiple homes are flooded or moved off foundations	Widespread disruption or loss of infrastructure identified in flood plans (e.g. railways, utilities, hospitals)
			Disruption to travel	Many cars will likely be submerged or washed away. Several sections of nearshore roads and escape routes will be impassable and a few could be washed out.	Several sections of roads and escape routes should be closed.
			Danger to life	Danger to life due to fast flowing / deep water / wave overtopping/ wave inundation	Large scale evacuation may be required

Minimal threshold: beach roads, boat launch ramps, wharves

Minor threshold: seasonal road, cottage access road/driveway, wharf roads and buildings

Major threshold: houses; commercial or other public facilities (restaurant, museum, information centre)

Severe threshold: main roads (or access roads to multiple houses)

	A	J	M	N	O	P	Q	R	S	T
1	Grid Cell	Area Name	Minimal	Minimal_Notes	Minor	Minor_Notes	Major	Major_Notes	Severe	Severe_Notes
77	76	Charlottetown East	1.4	parking lot	1.8	access roads to harbour/cr	1.5	restaurant (lobster on t	2.7	road/bridge (Fort Augustus?)
78	77	Stratford	0.9	shooting range building	2.4	access road (Keppoch bea	2.4	house	4.4	road/bridge (Keppoch rd)
79	78	NA								
80	79	Grand Tracadie	1	harbour buildings	0.9	road	1.6	house		
81	80	Johnstons River	1.5	beach road			1.2	house	2.7	road/bridge
82	81	Alexandra	0.8	back road			1.2	house	1.4	road/bridge
83	82	Point Prim					1.7	cottage/house	1.4	access road
84	83	Point Deroche	1.4	beach access road/parking			0.8	house	1.5	access road to cottage subdivision
85	84	Earnscliffe	2	wharf infrastructure	1.6	road to farm	2.5	cottage		
86	85	Pinette	1.4	wharf infrastructure	1.6	access road to wharf	1.6	house	3.3	road/bridge
87	86	Flat River	1.2	beach road			1.5	house	1.5	access road to houses
88	87	Savage Harbour	1.5	wharf infrastructure	0.9	access road to house	1.7	house	1.4	road/bridge
89	88	Orwell			1.2	access road to cottages	1.2	house	2	road access to houses
90	89	Belle River	1	beach road	1.2	access to fish plant	1.6	Commercial building (f	3.5	road/bridge

How are we going to do this?



5-Day Coastal Flooding Risk Outlook

- Coastal Flooding

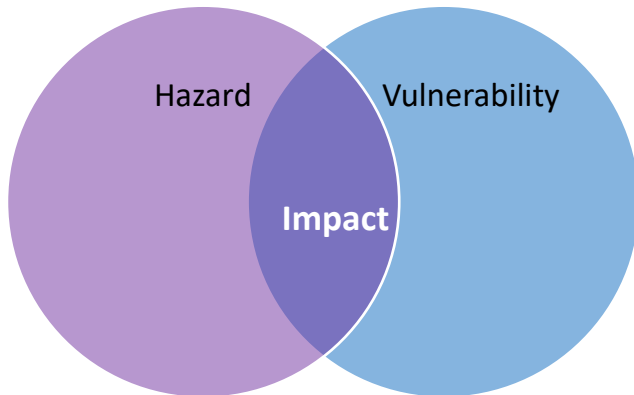
Hazard:

Some volume/level of water incident along the coast.

Impact:

Vulnerability:

Dependent on what that volume/level of water comes in contact with.



Risk:

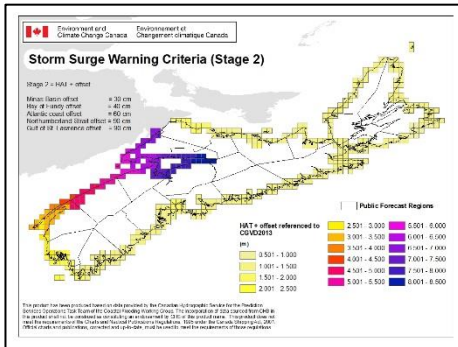
Is depended on the level of **Impact** and the **likelihood** of the (aka probability).

Probabability Probabilité	Risk Matrix / Matrice de risque			
> 60 %	Negligable Négligeable	Low Faible	Medium Moyen	High Haut
40%-<60%	Negligable Négligeable	Low Faible	Medium Moyen	Medium Moyen
20%-<40%	Negligable Négligeable	Negligable Négligeable	Low Faible	Medium Moyen
>0%-<20 %	Negligable Négligeable	Negligable Négligeable	Low Faible	Low Faible
Impact	Minimal	Minor Mineure	Significant Important	Severe Grave

How are we going to do this?



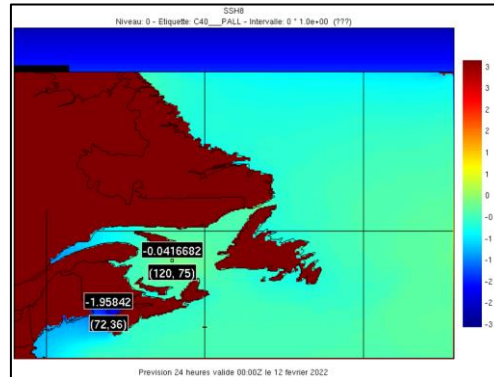
5-Day Coastal Flooding Risk Outlook



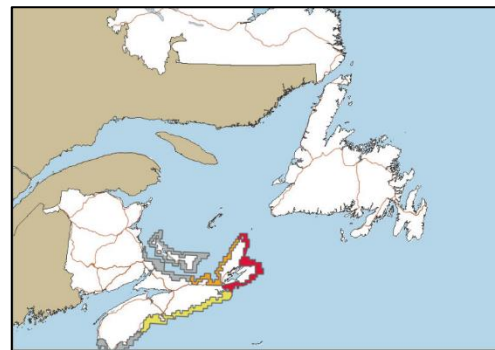
Water level impact thresholds ref to CVGD2013 based on information provide by Provinces and Territories

CVGD2013 -> HAT

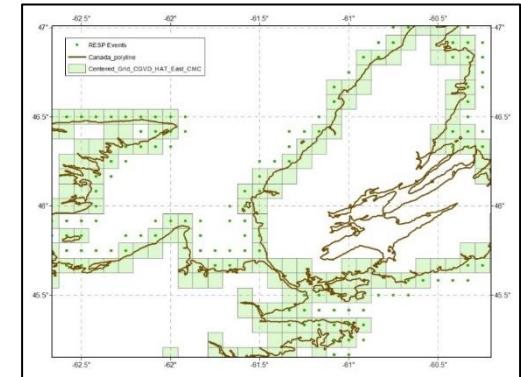
Convert water level impact thresholds from a geodetic ref to HAT to account for relative sea level rise as well as differences between harmonic and dynamic tidal predictions



24 hr Max percentiles of water level elevation referenced to model HAT



Daily Coastal Flooding Risk guidance



Mapping of model points to the coastal grid

Forecaster

Product Generators

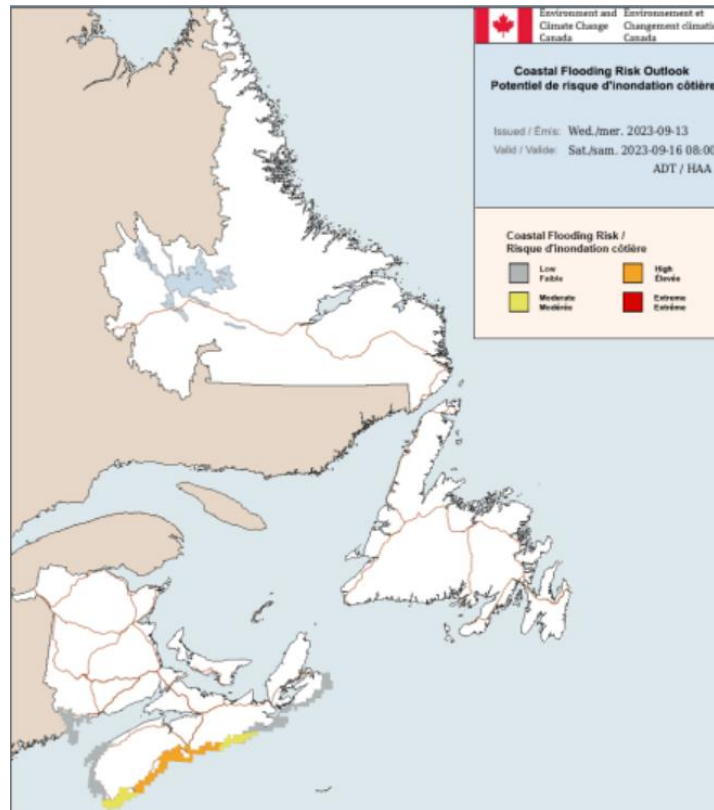
Dissemination

How are we going to do this?



5-Day Coastal Flooding Risk Outlook

- The Coastal Flooding Risk Outlook is a geo- and time-referenced, polygon product that will be issued by MSC to articulate the coastal flooding risk, impact and probability.
- This daily product is by Storm Prediction Centres and intended to provide early notification, out to 5 days, of coastal flooding due to astronomical tide, storm surge and wave impacts.
- 2 File types will be published to the DMS (currently on DMS Stability)
 - Png
 - GeoJSON

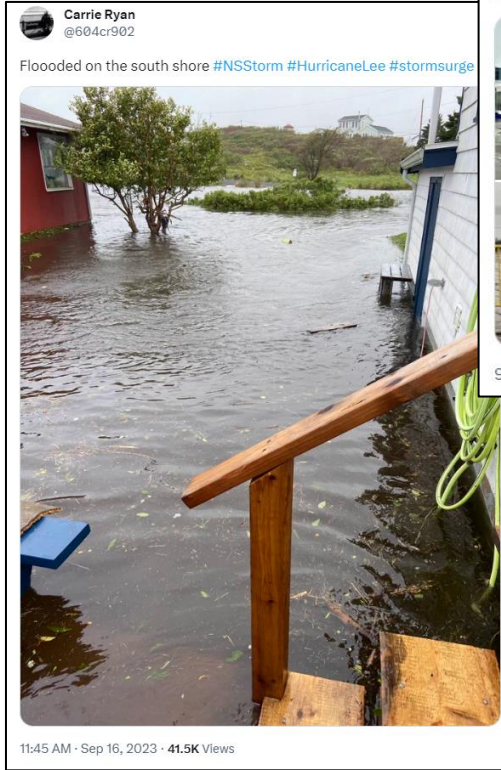


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How are we going to do this?



5-Day Coastal Flooding Risk Outlook



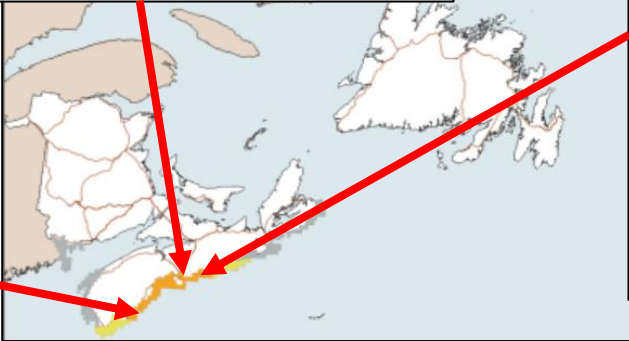
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Coastal Flooding Risk
Potentiel de risque d'inondation

Issued / Émis: Wed., / mar. 2
Valid / Valide: Sat., / ven. 20

Coastal Flooding Risk /
Risque d'inondation côtière

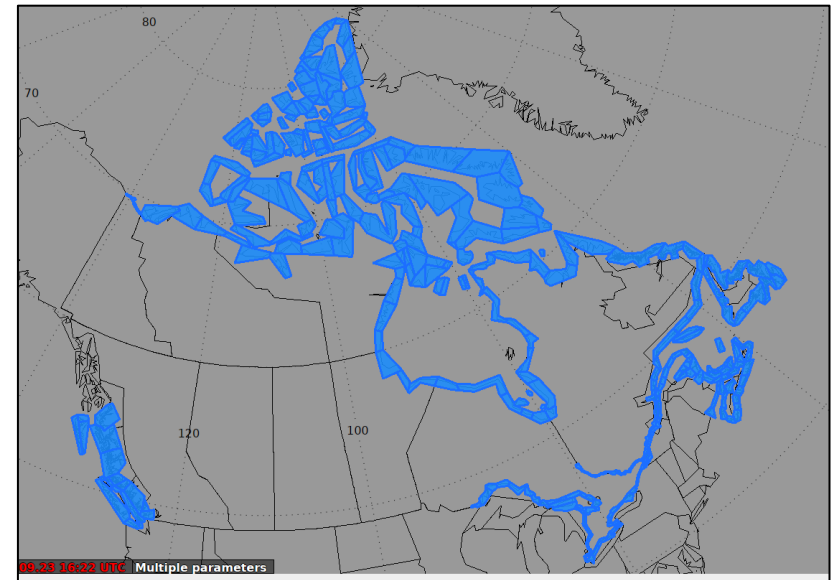
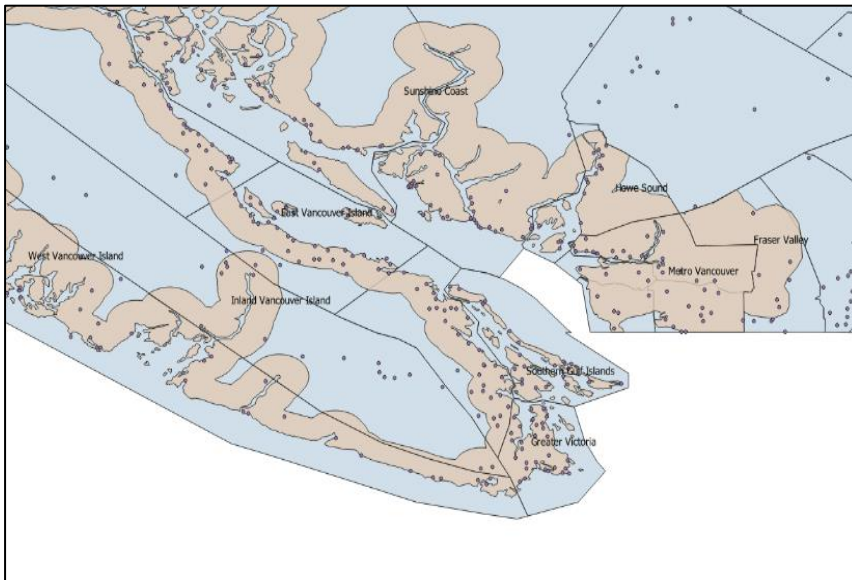
- Low / Faible
- Moderate / Modérée



How are we going to do this?..

 2023-03-20: MIPMB: Alert all of Canada's coastlines for Coastal Flooding/Storm Surge.

- A request of Board members to approve the introduction of ribbon polygons for Storm Surge Warnings to enable the capability for MSC to produce and disseminate Storm Surge Warnings for all of Canada's coastlines as part of the Predicting and Alerting for Coastal Flooding initiative.
- Currently there are large regions of Canada's coastline that do not have an existing public region that can be used to disseminate Storm Surge Warnings.

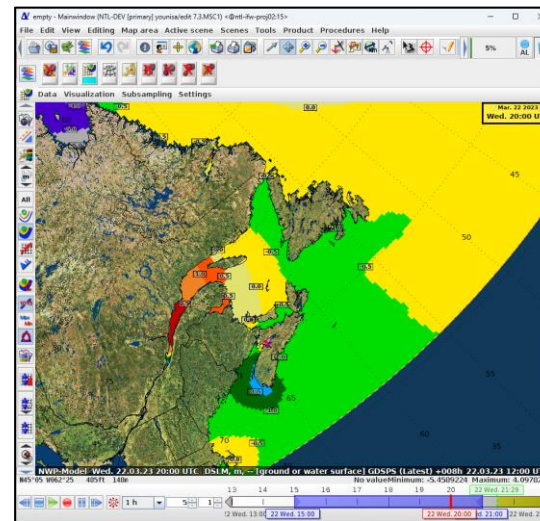
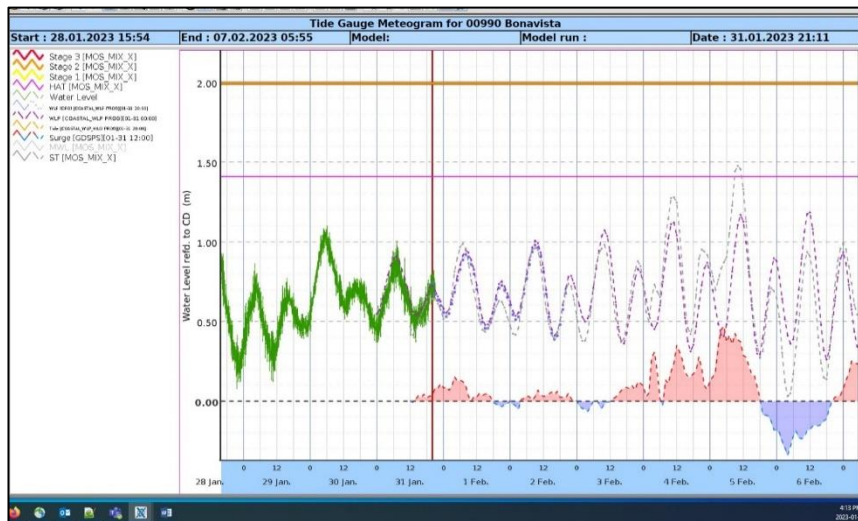


Opportunities for improvement: for the MT's



Predicting and Alerting of Coastal Flooding

- Operational Forecaster will have access to water level observation data in near real time
- Operational Forecaster will have access to the latest tide predictions, and heights (HAT, Record Water Level, etc) from DFO.
- Operational Forecaster will have access to visualize the operational numerical models that predict phenomena that attribute to coastal flooding
- Operational Forecaster will have a better understanding of client and/or stakeholder coastal flooding vulnerabilities



Opportunities for improvement: for the PT's



Predicting and Alerting of Coastal Flooding

1. Greater parity of service across the country
2. The emergency management (EM) community will be provided with early notifications (up to 5 days) of impending coastal flooding events
3. (EM) will have access to 24/7 coastal flooding alerts and predictions
4. (EM) will be provided with the uncertainties associated with coastal flooding predictions