2021 Hurricane Season Flood Alert System
Final Report

Department of Environment and Climate Change

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FINAL REPORT

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1 Flood Alerts Summary

The Wood Hurricane Season Flood Alert System (HSFAS) Product is the combination of professionally trained meteorologists applying their full knowledge of atmospheric science to Newfoundland and Labrador's weather patterns and combining these patterns with existing trends, known observations, and weather prediction models. Examining maximum precipitation predictions from many different dynamic models, allows forecasters to produce a better forecast of the maximum precipitation potential, based on the strength of different models in handling the atmospheric physics of differing weather patterns.

From June 2021 to December 2021, 56 alerts were issued in total. There were no missed alerts (i.e., the case when observations from a station trigger an alert that had not been issued). Monthly PDF reports containing all alerts have been provided to WRMD, and a summary of these alerts is below. Note that some communities have two alerts issued in one day. The second of the alerts was issued with an afternoon update forecast.

Table 1 Summary of Flood Alerts

	Site location	Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
1	Nain (NAIN A)	7-16-2021	53.2	56.0
2	Nain (NAIN A)	7-30-2021	53.3	73.4
3	Corner Brook	9-2-2021	65.1	77.1
4	Deer Lake, Steady Brook	9-2-2021	66.2	75.6
5	Bishops Falls	9-2-2021	72.4	95.4
6	Comfort Cove (COMFORT COVE)	9-2-2021	59.5	83.4
7	Gander (GANDER AIRPORT CS)	9-2-2021	63.2	82.5
8	Appleton/Glenwood	9-2-2021	61.1	84.1
9	Burgeo (BURGEO NL)	9-2-2021	95.8	120.7
10	Corner Brook	9-2-2021	62.0	71.8
11	Burgeo (BURGEO NL)	9-2-2021	101.0	120.7
12	Deer Lake, Steady Brook	9-2-2021	66.0	73.9
13	Bishops Falls	9-2-2021	72.4	95.4
14	Comfort Cove (COMFORT COVE)	9-2-2021	59.5	83.4
15	Appleton/Glenwood	9-2-2021	61.1	84.1
16	Gander (GANDER AIRPORT CS)	9-2-2021	76.0	82.5
17	Happy Valley-Goose Bay (GOOSE A)	9-9-2021	62.0	82.7
18	Happy Valley-Goose Bay (GOOSE A)	9-9-2021	62.3	93.9

	Site location	Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
19	Happy Valley-Goose Bay (GOOSE A)	9-9-2021	49.0	65.4
20	Bay Roberts (Shearstown)	9-17-2021	76.7	79.1
21	Mount Pearl, St. John's	9-17-2021	80.0	95.2
22	Bay Roberts (Shearstown)	9-17-2021	76.7	85.2
23	Mount Pearl, St. John's	9-17-2021	105.0	110.0
24	Mount Pearl, St. John's	9-18-2021	107.6	110.0
25	Petty Harbour, St. John's (Goulds)	9-18-2021	50.8	81.8
26	Churchill Falls	10-16-2021	50.8	81.8
27	Happy Valley-Goose Bay (GOOSE A)	10-16-2021	41.7	72.2
28	Churchill Falls	10-16-2021	47.9	67.4
29	Happy Valley-Goose Bay (GOOSE A)	10-16-2021	41.7	72.2
30	Churchill Falls	10-17-2021	46.1	69.5
31	Happy Valley-Goose Bay (GOOSE A)	10-17-2021	41.7	72.2
32	Churchill Falls	10-17-2021	55.0	62.3
33	Happy Valley-Goose Bay (GOOSE A)	10-17-2021	43.8	72.2
34	Churchill Falls	10-18-2021	43.1	56.2
35	Happy Valley-Goose Bay (GOOSE A)	10-18-2021	43.1	72.2
36	Deer Lake, Steady Brook	10-18-2021	53.3	70.8
37	Churchill Falls	10-18-2021	43.1	60.0
38	Happy Valley-Goose Bay (GOOSE A)	10-18-2021	62.0	75.0
39	Deer Lake, Steady Brook	10-18-2021	66.0	76.0
40	Channel-Port aux Basques (Port Aux Basques)	11-21-2021	158.1	230.0
41	Channel-Port aux Basques (Port Aux Basques)	11-22-2021	123.1	144.0
42	Burgeo (BURGEO NL)	11-22-2021	123.1	144.0
43	Channel-Port aux Basques (Port Aux Basques)	11-22-2021	115.0	200.0
44	Burgeo (BURGEO NL)	11-22-2021	73.0	108.0
45	Channel-Port aux Basques (Port Aux Basques)	11-23-2021	145.0	249.0
46	Burgeo (BURGEO NL)	11-23-2021	114.0	165.0
47	Mary's Harbour (MARY'S HARBOUR A)	11-23-2021	76.9	85.2
48	Battle Harbour (BATTLE HARBOUR LOR)	11-23-2021	76.9	85.2

	Site location	Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
49	Channel-Port aux Basques (Port Aux Basques)	11-23-2021	138.0	235.0
50	Burgeo (BURGEO NL)	11-23-2021	79.0	120.0
51	Mary's Harbour (MARY'S HARBOUR A)	11-23-2021	65.5	72.8
52	Battle Harbour (BATTLE HARBOUR LOR)	11-23-2021	65.5	72.4
53	Channel-Port aux Basques (Port Aux Basques)	11-29-2021	104.8	112.8
54	Channel-Port aux Basques (Port Aux Basques)	11-29-2021	99.2	104.7
55	Burgeo (BURGEO NL)	12-6-2021	85.1	104.8
56	Burgeo (BURGEO NL)	12-6-2021	90.2	104.8
Legend (WRMD or EC Exceeded flood limit)				
Exceeded 12-Hourly 20-yr flood limit				
Exceeded 12-Hourly 100-yr flood limit				
Exceeded 24-Hourly 20-yr flood limit				
Exceeded 24-Hourly 100-yr flood limit				

The 2021 season was less active than the 2020 season (56 vs 78 alerts). This is a result of a relatively dry and warm summer. Most of the alerts occurred in Autumn, and many were associated with an extreme precipitation event over southwest Newfoundland in late November.

Table 2 Monthly Analysis of Flood Alerts

Month	Total Alerts	12-hourly 20-yr alerts	12-hourly 100-yr alerts	24-hourly 20-yr alerts	24-hourly 100-yr alerts	Env. Can. & WRMD Obs.
June	0	0	0	0	0	0
July	2	2	0	0	0	0
August	0	0	0	0	0	0
September	23	14	2	4	3	0
October	14	2	0	9	3	0
November	15	2	10	2	1	0
December	2	2	0	0	0	0
Total:	56	22	12	15	7	0

The geographical spread of the alerts this season was not as large as in years past, with the majority occurring in southern Newfoundland and Labrador.

Table 3 Regional Analysis of Flood Alerts

Community	Region	Total Number of Alerts
Battle Harbour	Labrador	2
Churchill Falls	Labrador	6
Happy Valley-Goose Bay	Labrador	9
Mary's Harbour	Labrador	2
Nain	Labrador	2
Corner Brook	Western	2
Deer Lake, Steady Brook	Western	4
Appleton/Glenwood	Central	2
Bishop's Falls	Central	2
Comfort Cove	Central	2
Gander	Central	2
Burgeo	Southern	8
Channel Port aux Basques	Southern	7
Bay Roberts	Eastern	2
Mount Pearl, St. John's	Eastern	3
Petty Harbour, St. John's	Eastern	1

From a geographic perspective:

- Six (6) alerts were issued for the Western region
- Six (6) alerts were issued for the Eastern Region
- Eight (8) alerts were issued for the Central Region
- Fifteen (15) alerts were raised for the Southern Region,
- Twenty-one (21) alerts were issued for Labrador

This season's geographic variability is less large compared to previous years, meaning that the alerts were more concentrated as you move further west. This year, most of the alerts were issued for Southern and Labrador, with a general equal spread for other parts of the island. This is a reflection of the weather pattern during this period, where the storm tracks were situated towards the west of Newfoundland over the course of the season, with an extreme weather event taking place in November. In September, Hurricane Larry impacted eastern Newfoundland, but that event did not bring excessive rainfall amounts.

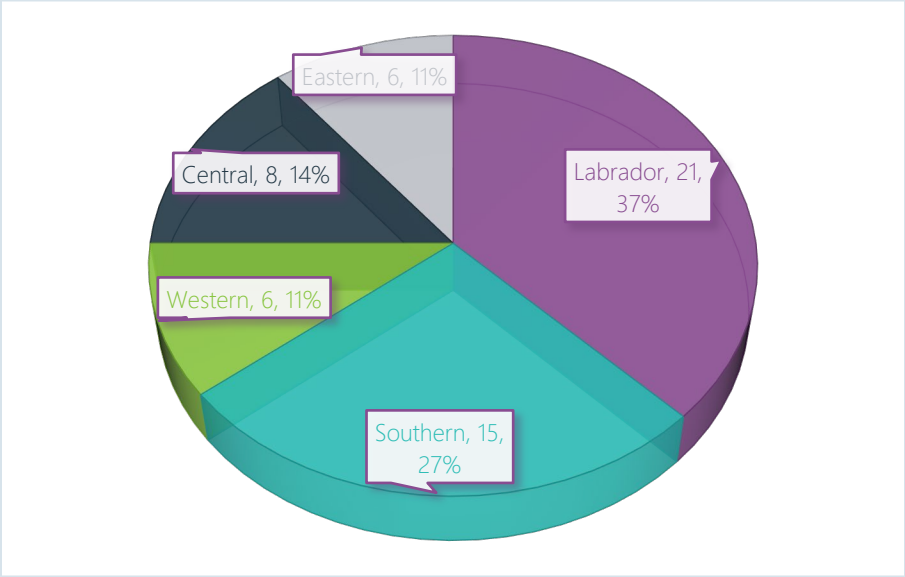

Figure 1. Alerts by Region

2 Verification of Alerts

The flood alerts were verified on a monthly basis using three data sources/methods to compare with the forecasted values. These data sources include: ECCC rain gauge data, WRMD rain gauge data, and qualitative community-based reports. However, there remains some significant challenges with verification. Rainfall has very high spatial variability, meaning that stations only a few kilometres apart may record vastly different values. Nearby gauge comparison is a limited verification method due to the intense variability of precipitation over the changing terrain and within small (meso-) scale atmospheric features.

Also, due to the risk involved with missed alerts, the implemented forecasting approach represents a worst-case scenario. The forecast is essentially the highest possible rainfall based on the current conditions instead of the most likely scenario rainfall. Every season, by design, there are many alerts issued that are not required. As such, any issued alert will generally overestimate what is observed, creating a large number of alerts that will not verify. The system was designed to avoid missing an alert, as the consequence for missed alerts is very serious for the people and resources involved.

2.1 Community Based Flood Reports

Wood works with Fire & Emergency Services – NL (FES-NL) whenever there are reports of flooding that may not have been forecasted. The concept was to create a qualitative field verification measurement that could further validate the statistical methods. Following a forecasted flood event, the intention was for local

officials to classify the event as having no, minor, or catastrophic flooding, and these eyewitness reports would be noted on the monthly verification. In the absence of community accounts, local newspapers and social media were scanned to verify the alerts qualitatively. This season, there were no reports of flooding that was not forecasted.

A severe weather event impacted southwest Newfoundland on November 22-23 as a frontal boundary stalled over the region. Rainfall totals of 165.1 mm were recorded at Port aux Basques weather station, although it is likely that areas to the north received even higher amounts. The event caused significant flooding and road washouts. Wood issued a total of four (4) 12-Hourly 100-yr flood limit alerts for the Port aux Basques region in advance of that event.

2.2 Potential Missed Alerts

There were no events triggered by stations exceeding the 20-year or 100-year limit amounts.

Table 4 Potential Missed Alerts

Community	Nearby Flood Report	Issue Date	12-hour Precip Forecast	24-hour Precip Forecast	EC Observed	WRMD Observed	Conclusion
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2.3 Climate Normals

Airport reports of rainfall across NL were examined to determine how the 2021 HSFAS season compared to the climatological normals. The 2021 months are colour-coded in red if they were substantially above normal and blue if they were substantially below normal.

Table 5 Monthly Rainfall Totals (in millimetres) compared to climate normals

Location	Jun 2021	Jun Norm	Jul 2021	Jul Norm	Aug 2021	Aug Norm	Sep 2021	Sep Norm	Oct 2021	Oct Norm	Nov 2021	Nov Norm	Dec 2021	Dec Norm
St. John's	71.2	97.5	114.4	91.6	50.8	100.0	109.8	129.6	131.6	153.7	176.7	124.8	100.9	102.9
Gander	30.4	85.7	46.3	95.4	52.0	104.2	131.5	114.7	86.2*	102.3	77.2*	75.2	41.9*	48.9
Deer Lake	86.6	87.8	160.5*	95.1	90.7	109.6	208.1	99.9	137.0	84.9	63.9*	60.2	11.2*	27.6
Goose Bay	130.6^	90.0	67.6^	121.3	165.9^	99.3	136.3^	90.6	95.3^	63.3	116.3^	22.7	159.6^	6.6

Notes:

* Note that data was missing at the site for one or more days

^ Note that amounts are total precipitation, not total rainfall

2.4 Summary

June was above normal for rainfall across Labrador, including Goose Bay, but below normal across central and eastern Newfoundland. July saw wetter than normal conditions for St. John's and Deer Lake but below normal conditions for Gander and Goose Bay. August was significantly wetter than normal across Labrador and Goose Bay but slightly below normal over western Newfoundland and Deer Lake and well below normal in Gander and St. John's. September was wet for Goose Bay and very wet for Deer Lake with precipitation amounts more than twice the normal average. Rainfall was relatively close to normal for central and eastern Newfoundland. Precipitation was well below normal for St. John's in October, but moving west, precipitation amounts increased and were above normal for Deer Lake and Goose Bay. Rainfall was above normal in St. John's for November and December and near normal elsewhere in Newfoundland. Precipitation amounts were generally above normal in Goose Bay in November and December. Please note that there were missing data for some of the sites, as noted in the table above.

Overall, 2021 was another very active tropical weather season in the Atlantic as there were 21 named storms. The remnants of Hurricane Elsa passed over western Newfoundland in July, but the impacts were minimal. Hurricane Larry, however, passed over the western Avalon Peninsula on the late evening of September 11. Larry was responsible for very high wind gusts across eastern Newfoundland however, by the time the system passed over the Province, it had lost a lot of the moisture it had been associated with. The highest rainfall amount recorded occurred at Port Rexton, with only 37.5 mm.

3 Lessons Learned

The geographic spread of alerts and flooding events from this season were unique compared to previous seasons. As individual seasons continue to depart further from climate normals, customized alerting services such as this become more critical. Record-breaking dry or wet spells emphasize the growing importance of nowcasting and advanced weather monitoring on a very local scale.

Flooding is a complex phenomenon and can occur with amounts significantly less than the 20-year or 100-year thresholds and vice versa – no flooding may occur with amounts significantly higher than those. The HSFAS product, along with the services provided by WRMD, such as water level monitoring and reporting, are key components that work well together to help provide advance warnings to communities to better prepare for potential flooding.

Validation and incremental improvements to the HSFAS service is aided by having a network of observations. While a product such as the ECCC Canadian Precipitation Analysis (CaPA) would help, this still represents a precipitation model which could vary significantly from true observations. As we have indicated in the past, the best solution would be to fill the gaps in the available monitoring networks. Using only the ECCC and WRMD gauge data limits our ability to verify the forecasts in some areas. Many communities require additional measurements, access, and/or studies. Without adequate instrumentation for measuring precipitation, it can be almost impossible to know for certain in high terrain areas whether the forecasted precipitation was accurate. Attempts have been made to fill these gaps through community-based flood reports and the use of local media sources to try to collaborate sparse gauge data.

The 2022 WRMD project to team with the NL Department of Transportation and Infrastructure (NLDTI) to add rain gauges to the NLDTI Road Weather stations should help with the forecasting and validation for the upcoming season.

4 Conclusion

It would be beneficial to pursue additional improvements to the data sources:

1. Additional rain gauges could be installed, particularly in the regions that generated significant alerts.
2. Flood Risk Mapping Studies could be considered for the communities that triggered alerts based on Intensity-Duration-Frequency (IDF) curves.

5 Closure

We trust that this report meets your needs. Please do not hesitate to contact the undersigned if you have any questions or comments regarding the hurricane season outlook.

Yours sincerely,

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