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2018 Hurricane Season Flood Alert System Final Report

Department of Municipal Affairs and Environment

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1 Flood Alerts Summary

The Wood Hurricane Season Flood Alert System (HSFAS) Product is the result of professionally trained meteorologists applying their full knowledge of atmospheric science to Newfoundland and Labrador's weather patterns and pairing that 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 July 2018 to December 2018, 72 alerts were issued in total. These include five events where the Environment and Climate Change Canada (ECCC) data exceeded alert limits, two of which have been determined to be due to erroneous data. The other three had their validation passed with the following forecasts (i.e., they were missed on an early issuance but correctly forecasted closer to the event). An excel spreadsheet of all the flood alerts issued has been provided to WRMD, and a summary of these alerts are below.

Table 1 Summary of Flood Alerts

Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
1	Gander (GANDER AIRPORT CS)	6/25/2018 20:00	61	49
2	Glovertown	6/25/2018 20:00	60	49
3	Cold Brook, Kippens (Gaudon's Brook)	6/29/2018 9:00	71	73
4	Cold Brook, Kippens (Gaudon's Brook)	7/5/2018 9:00	35	36
5	Gander (GANDER AIRPORT CS)	7/11/2018 9:00	43	43
6	Appleton/Glenwood	7/11/2018 16:00	60	64
7	Gander (GANDER AIRPORT CS)	7/11/2018 16:00	65	70
8	Glovertown	7/11/2018 16:00	66	70
9	Hickman's	7/11/2018 16:00	79	82

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Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
	Harbour-Robinson			
10	Hodges Cove	7/11/2018 16:00	78	82
11	Clarenville (Shoal Harbour)	7/11/2018 16:00	82	85
12	Gander (GANDER AIRPORT CS)	7/12/2018 9:00	61	70
13	Glovertown	7/12/2018 9:00	65	73
14	Cold Brook, Kippens (Gaudon's Brook)	7/14/2018 9:00	7	8
15	Wabush (WABUSH LAKE A)	7/16/2018 9:00	49	51
16	Corner Brook	7/16/2018 9:00	54	54
17	Wabush (WABUSH LAKE A)	7/23/2018 9:00	47	52
18	Churchill Falls	7/25/2018 9:00	45	66
19	Daniel's Harbour (DANIELS	8/8/2018 9:00	86	94

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Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
20	Wabush (WABUSH LAKE A)	8/21/2018 9:00	43	53
21	Churchill Falls	8/21/2018 16:00	41	57
22	Wabush (WABUSH LAKE A)	8/21/2018 16:00	58	70
23	Churchill Falls	8/22/2018 9:00	55	68
24	Wabush (WABUSH LAKE A)	8/22/2018 9:00	54	47
25	Churchill Falls	8/22/2018 16:00	61	98
26	Wabush (WABUSH LAKE A)	8/22/2018 16:00	55	63
27	Churchill Falls	8/23/2018 9:00	100	116
28	Wabush (WABUSH LAKE A)	8/23/2018 9:00	44	36
29	Churchill Falls	8/28/2018 9:00	44	46

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Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
30	Happy Valley-Goose Bay (GOOSE A)	8/28/2018 9:00	62	50
31	Wabush (WABUSH LAKE A)	8/28/2018 9:00	43	45
32	Happy Valley-Goose Bay (GOOSE A) Bay	8/28/2018 16:00	59	65
33	Whitbourne	10/11/2018 9:00	81	84
34	Bay Roberts (Shearstown)	10/11/2018 9:00	79	81
35	Burgeo (BURGEO NL)	10/19/2018 9:00	90	142
36	Deer Lake, Steady Brook	10/19/2018 9:00	49	72
37	Gander (GANDER AIRPORT CS)	10/19/2018 9:00	47	64
38	Corner Brook	10/19/2018 9:00	60	89
39	Burgeo (BURGEO NL)	10/20/2018 9:00	100	139
40	Deer Lake, Steady Brook	10/20/2018 9:00	60	75
41	St. Alban's (ST ALBANS)	10/20/2018 9:00	95	132

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Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
42	Corner Brook	10/20/2018 9:00	58	77
43	Appleton/Glenwood	10/20/2018 9:00	62	96
44	Burgeo (BURGEO NL)	10/20/2018 9:00	93	119
45	Cold Brook, Kippens (Gaudon's Brook)	10/20/2018 9:00	85	88
46	Deer Lake, Steady Brook	10/20/2018 9:00	64	80
47	Gander (GANDER AIRPORT CS)	10/20/2018 9:00	73	95
48	Glovertown	10/20/2018 9:00	72	94
49	St. Alban's (ST ALBANS)	10/20/2018 9:00	102	156
50	Stephenville	10/20/2018 9:00	80	88
51	Stephenville Crossing, Black Duck Siding	10/20/2018 9:00	82	88

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Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
52	Corner Brook	10/20/2018 9:00	60	88
53	Appleton/Glenwood	10/21/2018 9:00	94	65
54	Bishops Falls	10/21/2018 9:00	94	78
55	Burgeo (BURGEO NL)	10/21/2018 9:00	102	107
56	Cold Brook, Kippens (Gaudon's Brook)	10/21/2018 9:00	82	70
57	Comfort Cove (COMFORT COVE)	10/21/2018 9:00	73	55
58	Deer Lake, Steady Brook	10/21/2018 9:00	66	67
59	Gander (GANDER AIRPORT CS)	10/21/2018 9:00	81	66
60	Glovertown	10/21/2018 9:00	71	70

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Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
61	Hickman's Harbour-Robinson	10/21/2018 9:00	70	82
62	Hodges Cove	10/21/2018 9:00	70	82
63	Clarenville (Shoal Harbour)	10/21/2018 9:00	70	83
64	St. Alban's (ST ALBANS)	10/21/2018 9:00	105	118
65	St. Lawrence (ST LAWRENCE)	10/21/2018 9:00	104	96
66	Stephenville	10/21/2018 9:00	82	70
67	Stephenville Crossing, Black Duck Siding	10/21/2018 9:00	86	70
68	Corner Brook	10/21/2018 9:00	64	64
69	Burgeo (BURGEO NL)	10/24/2018 9:00	68	103
70	Burgeo (BURGEO NL)	10/27/2018 9:00	53	87

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Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
71	Burgeo (BURGEO NL)	10/28/2018 9:00	83	109
72	Burgeo (BURGEO NL)	10/28/2018 16:00	98	110

Note:

Exceeded 12-Hourly 20-yr flood limit	Exceeded 24-Hourly 20-yr flood limit
Exceeded 12-Hourly 100-yr flood limit	Exceeded 24-Hourly 100-yr flood limit
WRMD or EC Exceeded flood limit	

The 2018 season was significantly more active than the 2017 season. The 2018 Alerts/events (total of 72) were noticeably more than 2017 (total of 13). The increase is due to a large event in October, which alone triggered 34 alerts, as well as several events from June through August. No alerts were issued in September (the month was dry), November and December (the months were dry/cold and precipitation fell as mostly snow).

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	3	3	0	0	0	0
July	15	8	0	3	1	3
August	14	7	6	1	0	0
September	0	0	0	0	0	0
October	40	20	6	6	6	2
November	0	0	0	0	0	0
December	0	0	0	0	0	0
Total:	72	38	12	10	7	5

The geographical spread of the alerts this season was large, spanning the entire province.

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Table 3 Regional Analysis of Flood Alerts

Community	Region	Total Number of Alerts
Churchill Falls	Labrador	6
Happy Valley-Goose Bay	Labrador	2
Wabush	Labrador	8
Corner Brook	Western	5
Daniel's Harbour	Western	1
Deer Lake, Steady Brook	Western	4
Stephenville	Western	2
Stephenville Crossing, Black Duck Siding	Western	2
Appleton/Glenwood	Central	3
Bishops Falls	Central	1
Cold Brook, Kippens	Central	5
Comfort Cove	Central	1
Gander	Central	7
Glovertown	Central	5
Bay Roberts	Eastern	1
Clarenville	Eastern	1
Hickman's Harbour-Robinson	Eastern	2
Hodge's Cove	Eastern	2
Whitbourne	Eastern	2
Burgeo	Southern	8
St. Albans	Southern	3
St. Lawrence	Southern	1

From a geographic perspective, fourteen (14) alerts were triggered for the Western region, eight (8) alerts were issued for the Eastern Region, twenty-two (22) alerts were issued for the Central Region, twelve (12) alerts were issued for the Southern Region, and sixteen (16) alerts were issued for Labrador. This season's geographic variability is large, with the Central Region receiving the most alerts. Last year, the Central Region did not receive any alerts, which presents significant spatial variability between the two years.

2 Verification of Alerts

The flood alerts were verified on a monthly basis using three data sources/methods to compare with the forecasted values: ECCC rain gauge data, WRMD rain gauge data, and qualitative community-based reports. However, there remain 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.

Due to the risk involved with missed alerts, the forecasting approach that was implemented represents a

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worst-case scenario. The forecast is essentially the highest possible rainfall based on the current conditions as opposed to the most likely scenario rainfall. Every season, by design, there is a large number of 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 in this manner to avoid missing an alert as the consequence for missed alerts are very serious for the people and resources involved.

For the 2018 season, validation was not possible for 29 alerts due to no nearby gauges to provide a comparison.

2.1   Community Based Flood Reports

Wood worked with Fire & Emergency Services – NL (FES-NL) this season, with monthly calls to discuss the alerts. 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.

2.2   Potential Missed Alerts

We could not find any reports of flooding in the province during the 2018 season (June-December). Five potential events were triggered by stations exceeding 20 or 100-year limit amounts. Two of these were triggered by a WRMD station exceeding a 100-year amount for Cold Brook/Kippens on July 6 and July 15 with 203 and 115 mm reported respectively; we believe that both reports are erroneous due to the extreme values reported and the synoptic weather setup at the time. The other three were triggered by Environment Canada stations exceeding 20-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
Gander	N/A	12-Jul	43 mm	43 mm	61 mm	N/A	Amount higher than forecasted
Gander	N/A	21-Oct	47 mm	64 mm	80 mm	N/A	Amount higher than forecasted
Burgeo	N/A	28-Oct	53 mm	87 mm	107 mm	N/A	Amount higher than forecasted

None of the potential missed events caused flooding, to the best of our knowledge. Forecasted amounts

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are approximately 20-40% lower than what was observed for these three events.

It should be noted that the four potentially missed events above represent a single forecast. The following forecasts were raised correctly and in that they passed the required validation (an alert was issued that exceeded thresholds and the observation confirmed that the thresholds were exceeded). This shows that forecast accuracy increases closer to the event and that while some events may be missed early on, all of the events were correctly predicted with a shorter lead time. The following individual alerts passed validation:

- Gander on July 12, with 61 mm/12 hrs forecasted. 61 mm/12 hrs was observed at the EC station.

- Gander on October 21, with 95 mm/24 hrs forecasted. 79 mm/24 hrs was observed at the EC station.

- Burgeo on October 28, with 109-110/24 hrs mm forecasted. 107 mm/24 hrs was observed at the EC station (2 alerts).

2.3   Climate Normals

Airport reports of rainfall across NL were examined to determine how the 2018 HSFAS season compared to the climatological normal. In the below table, 2018 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 2018	Jun Norm	Jul 2018	Jul Norm	Aug 2018	Aug Norm	Sep 2018	Sep Norm	Oct 2018	Oct Norm	Nov 2018	Nov Norm	Dec 2018	Dec Norm
St. John's	139.4	97.5	64.6	91.6	84.8	100.0	125.2	129.6	184.8	153.7	133.8	124.8	40.8	102.9
Gander	103.6	85.7	113.8	95.4	39.8	104.2	83.4	114.7	185.2	102.3	80.1	75.2	15.8	48.9
Deer Lake	77.0	87.8	60.1	95.1	88.4	109.6	145.5	99.9	172.0	84.9	76.4	60.2	25.8	27.6
Goose Bay	55.6	90.0	187.8	121.3	124.0	99.3	47.4	90.6	29.6	63.3	1.0	22.7	5.8	6.6

June was wetter than average in eastern and central Newfoundland due to an active storm pattern and drier than average in Labrador due to all storms passing over Newfoundland; July and August saw generally the opposite pattern. September varied across Newfoundland, with below-normal conditions in central and above-normal in western; Labrador was below normal. October was the wettest month of the year across Newfoundland, with four major rainstorms affecting the Island, as well as small events scattered throughout the month. November was near normal for wetness in Newfoundland and drier than normal in Labrador. December was drier than normal across the province.

Only two actual hurricane or tropical storm remnants reached Newfoundland this season, Beryl and Chris, both in early July, but neither caused significant precipitation. However, interactions by systems of non-tropical origin with distant tropical systems did have impacts on the province by channeling moisture from the tropics and contributing to some of the significant rainfall events.

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2.4   Summary

The current validation process is limited to invaluable scattered rain gauges and local community reports as they become available. Furthermore, localized media is used to support reported flooding cases. There were 29 alerts out of the 72 that were not verified due to the absence of rain gauges or local reports. There were no reports of floods from June to December of the 2018 season across the entire province. Five events triggered the 20-yr and 100-yr limit amounts. It was concluded that two of the events were erroneous due to their extreme observed values. The gauge observations from the other three events were compared to our forecast. It appeared that the forecasted values were 20% to 40% lower than the gauge observations. It should be noted that none of the latter events triggered floods in the area. The climatological data reveals October 2018 as the wettest month in Newfoundland while July 2018 was the wettest month in Goose Bay.

3   Service Improvement

The 2018 season (June to December) is considered substantially more active than the previous season. Although no recorded flood events occurred this season, the data shows potential flooding events being triggered due to amounts exceeding the 20-yr limit amounts. It is worth noting that such customized products are becoming more valuable under the witnessed weather pattern variability in the last decades. The localization nature of certain events triggering flooding alerts is also emphasizing the need to enforce this product with new techniques to optimize its use.

Wood would like to recommend increasing the number of gauges. Although it is important for rain gauges to be installed near communities, installing gauges in strategic locations where below threshold rainfall amounts can trigger flooding events in communities downstream is highly recommended.

Wood has the capabilities of producing 12-hr and 24-hr radar-based rainfall estimation in post storm analysis. The radar data can be used in conjunction with gauge data to derive a higher spatial corrected rainfall estimation. One of two different methods are used in this process, namely: The Mean Field Bias Correction Method and the Inverse-Distance Weighting Method. The final product can be displayed as geo-referenced files, images, animation, and gridded data in CSV formats. The CSV files can be displayed on GIS software as gridded data with 1kmx1km spatial resolution. Data from the two available radar stations covering Newfoundland (Holyrood and Marble Mountain) in conjunction with the WRMD and ECCC gauge data can be utilized to produce a higher spatial resolution rainfall data.

Given the need to serve the communities with a higher resolution data, Wood would like to initiate a discussion with WRMD to potentially provide a higher resolution radar-gauge based rainfall estimation as described above. Furthermore, we would like to discuss the potential of providing such service in near-real time to optimize the use of this technology.

4   Conclusion

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

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1. Wood would like to conduct an analysis study to increase the number of rain gauges and find the optimal locations for the new gauges.
2. Incorporate the Newfoundland Department of Transportation Road Weather Information System rain gauges in the system.
3. Provide a high spatial resolution radar-gauge based rainfall estimation in post storm and near real-time mode.
4. 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,

Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited

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