

**WEATHER FORECAST SERVICES FOR 2014-2015 FLOOD ALERT
AND FLOOD FORECASTING SERVICES**

**FOR THE GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
ISSUED FOR 2014-2015**

HURRICANE SUMMARY REPORT

Submitted to:

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c/o Government Purchasing Agency
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Submitted by:

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1. SUMMARY OF 2014 ATLANTIC HURRICANE SEASON OUTLOOK

In June 2014, AMEC provided an Atlantic Hurricane Season outlook for WRMD. Forecasters predicted that the Atlantic Basin would have a near to below normal season, and that Newfoundland was mostly likely to be impacted by 1-3 tropical/post-tropical cyclones through the hurricane season.

As indicated in the outlook report, there were several factors favouring a near-normal or below-normal hurricane season for the Atlantic Basin:

- The development of El Niño over the summer.
- Sea-surface temperatures (SST) in the Main Development Region (MDR) of the Atlantic Ocean were expected to remain near average to below average.
- We were in the warm phase of the Atlantic Multidecadal Oscillation (AMO) going into the hurricane season but there was not sufficient evidence to support a continuation of this warm phase.

These reasons pointed to less hurricane potential for the Atlantic Basin as a whole. Examining SST anomalies over three climatologically similar years from the past decade as described in the pre-season outlook report, the 2002 season was highlighted as having a similar temperature regime with warm anomalies off the mid-Atlantic coastal waters and cool anomalies surrounding Newfoundland, concentrated over the southern Grand Banks. The aforementioned warm anomalies off the mid-Atlantic coastal waters in combination with the establishing wind shear to the south due to the expected building of El Niño would have favoured tropical cyclone formation north of the Caribbean Sea and east of the southeastern U.S. this year, similar to 2002. Such cyclones tend to track towards the northeast and impact Newfoundland. This last point led us to our prediction of 1-3 tropical/extratropical cyclones to affect Newfoundland this season.

2. POST-SEASON ANALYSIS OF HURRICANE SEASON

The Atlantic Hurricane Season in general was below normal, with strong stability, dry air aloft and cooler-than-expected SSTs inhibiting the growth of many hurricanes. All 8 named storms from the 2014 Atlantic Hurricane Season are listed below, along with a brief summary of their impact on Newfoundland. More details regarding the 3 storms that most impacted NL follow.

Storm	Max Strength	Duration	Impact on NL
Hurricane Arthur	Category 2	July 1 - 5	Minimal Impact
Hurricane Bertha	Category 1	August 1 - 6	None
Hurricane Cristobal	Category 1	August 23 – 29	Minimal Impact
Tropical Storm Dolly	Tropical	September 1 - 3	None
Hurricane Edouard	Category 3	September 11 - 19	None
Hurricane Fay	Category 1	October 10 - 13	None
Hurricane Gonzalo	Category 4	October 12 – 19	Moderate Impact
Tropical Storm Hanna	Tropical	October 22 - 28	None

Hurricane Arthur

On June 25, a low pressure system began to develop over the Southeastern US, moving out over the Atlantic Ocean a few days later. The low slowly battled moderate wind shear and intrusions of dry air through the end of June, finally developing enough organized convection and steady circulation to be named Tropical Storm Arthur on July 1. Arthur then began tracking northeastward, obtaining Category 1 hurricane status on July 3. Hurricane Arthur intensified to Category 2 on July 4 and made brief landfall over North Carolina before continuing northeast over the Atlantic. The storm weakened and its eye dissipated as it crossed over colder seas, encountering increasing wind shear as it merged with a cold front.



Arthur continued to lose organization and completed conversion to an extratropical system on July 5 as it tracked over the Bay of Fundy. Arthur tracked over the Maritimes and passed by the west coast of Newfoundland on July 6 before dissipating over the Labrador Sea on July 7.

Hurricane Arthur caused significant power outages through the Maritimes and Quebec due to high winds. Damage in Nova Scotia and New Brunswick was extensive, with gusts over 135 km/h reminiscent of the destruction of Hurricane Juan in 2003. The electricity grid in New Brunswick took a particularly hard hit and the province is still recovering from it. Winds and rain were highest to the northwest of the storm track as the cold front funneled most of Arthur's moisture, sparing Newfoundland the damage that was seen over the Maritimes. Newfoundland did experience some gusty winds and rainfall, but there was no widespread damage.

Hurricane Cristobal

In mid-August, an area of low pressure developed over the Atlantic Ocean off the coast of Africa. The trough slowly moved west, gaining strength and organization from August 20 – 23. The storm began to develop organized circulation as it moved into the Caribbean, becoming Tropical Storm Cristobal early on August 24th. Cristobal became a Category 1 hurricane on August 25 and delivered several days of heavy rainfall to the Caribbean islands before turning northward.



Cristobal began to lose strength on August 29th, when it was downgraded to an extratropical storm. It tracked east of Newfoundland, merged with a larger trough of low pressure, and finally passed by Iceland at the end of August before dissipating. In the wake of the storm, strong northerly gusts developed along the Avalon, with peak gusts recorded near 90 km/h.

While passing near Newfoundland, the combined low caused moderate to rough surf and noticeably impacted harbour water levels over the Avalon and Peninsulas due to the speed at which it traversed the Grand Banks (exceeding 100 km/h). Heavy rain, more so due to the non-tropical low pressure system that Cristobal merged with, was reported over the Avalon Peninsula, with amounts generally from 40-60 mm.

Hurricane Gonzalo

On October 11, a low pressure trough formed over the Atlantic Ocean, just east of the Caribbean. The low strengthened rapidly over the next few days as it slowly tracked northwest, becoming Tropical Storm Gonzalo on October 12. The tropical storm started out small, battling dry air in the region, but thanks to extremely warm seas and low wind shear, Gonzalo was able to develop an eye and strong convection. Gonzalo achieved hurricane status as it passed by the Caribbean on October 13, rapidly intensifying through Category 2 and 3 before finally reaching Category 4 status on October 15. Prior to Gonzalo, the last Atlantic hurricane to reach Category 4 strength was Hurricane Ophelia in 2011.



Several eyewall replacement cycles then occurred, which means that the center of the storm was disrupted and this temporarily weakened the storm. Once this cycle stopped, the storm intensified again on October 16. Driven by a trough sweeping over the US, Gonzalo then turned and began tracking northeastward, weakening to a Category 2 storm on October 17 and making landfall over Bermuda early on October 18.



Hurricane Gonzalo continued its northeast track on October 18, maintaining Category 1 hurricane force as it passed southeast of Newfoundland in the early morning hours of October 19. Due to the angle and speed at which Gonzalo approached Newfoundland, the hurricane generated high waves, with seas in the 5 – 8 metre range observed along the south coast of the Avalon. Seas of up to 11 metres were recorded offshore. There was the potential for storm surge to cause some coastal flooding, but the highest waves hit at low tide and no significant coastal flooding was reported.

Heavy rain of 30-70 mm fell over the Avalon Peninsula, causing some short-lived flooding in the St. John's metro area where 50 – 60 mm were recorded across the City. Wind reports over the Southeast Avalon were strong, with wind gusts near 100 km/h observed on land and over 120 km/h reported by the offshore oil rigs. Within St. John's, winds gusted to 74 km/h, causing minor damage.

After impacting Newfoundland, Gonzalo traversed over colder seas and wind shear increased enough to transition the storm to extratropical. The remnants of Gonzalo headed for Europe and made landfall in Britain on October 21, where several fatalities were reported due to the high winds and heavy rainfall. A few days later, an unseasonably cold trough combined with Gonzalo and the resulting system brought an early crippling snowfall to Bulgaria on October 25 and substantial flooding to Greece on October 26.

3. VERIFICATION OF THE OUTLOOK

It was considered a quiet year for Atlantic hurricanes, with only eight named storms occurring. The last time there were only 8 named storms or less was nearly 20 years ago. The overall duration of the named storms (named storm days) was the lowest in the past 5 years.

There were several reasons that the Atlantic Hurricane Season was not as active as usual:

- **Presence of El Niño:** The Ocean Niño Index (ONI), an index measuring El Niño, remained slightly above normal through the hurricane season, particularly during the average seasonal peak during August-September-October.

The weak El Niño caused some vertical wind shift in the development region, which was responsible for the overall suppression of hurricane activity.

- **Stability and Vertical Wind Shear:** The tropical Atlantic showed sea level pressures above normal, which signifies stability and inhibits the strengthening of hurricanes. There was strong wind shear through the Caribbean, particularly in September, which reduced the ability for storms to organize. There was more subsidence occurring in the atmosphere as well, which further suppressed development.
- **Lack of available moisture:** The air over the Atlantic Basin was generally dry this season, so there was not as much moisture to fuel the development of tropical cyclones. Hurricanes thrive on moist environments and utilize that energy to grow, so they were limited by a lack of available moisture, particularly in the beginning of the season.

Although the Atlantic Basin overall was calmer than usual, Newfoundland saw slightly more than average activity from named storms; however, impacts and damage were not significant. Newfoundland sustained minimal to moderate impact from 3 named storms, which falls at the top of our outlook prediction for 1 – 3 impacts this season. The major factors driving impact on NL were:

- **Late-season Sea Warming:** The sea surface temperatures through the spring were cold throughout the tropics and off the coast of Newfoundland, though there were some warm pockets off the Eastern Seaboard of the US. Warm waters above 27° C are needed to keep the atmosphere unstable above a developing tropical system to sustain development. At the start of the hurricane season, a negative North Atlantic Oscillation developed (NAO), which caused a warming to occur and continue through the end of the season, giving fuel to several late-season storms and leading to a very active October. In particular, July was the hottest month on record across many parts of Newfoundland, completely erasing the preceding negative SST anomalies. This paved the way for stronger-than-normal storms to track over the abnormally warm waters near Newfoundland. This helped Hurricane Gonzalo to track as a rare hurricane well north of the Grand Banks before eventually undergoing extratropical transition.
- **Extratropical Transition:** Most of the storms that impacted Newfoundland were undergoing their transition from hurricane to extratropical storm, which is a dynamic and intense part of the life cycle of hurricanes. The storms that most impacted NL were driven and often combined with non-tropical low pressure systems and troughs which steered the storms. The troughs over the Eastern US seaboard kept pushing the hurricanes offshore and on a path toward Newfoundland. This has been an ongoing trend over the past several years and the US has now passed almost a decade without a major (Cat 3 or higher) hurricane making landfall. However, this means that the storms approach Atlantic Canada with more energy. When the storms make landfall in the US, their source of moisture and warmth is removed from the equation and they quickly lose steam. When the hurricanes avoid landfall in the south and rapidly approach Newfoundland with full strength, Atlantic Canada tends to see more destructive landfalls and storm impact.
- **Storm Strength:** There were fewer storms in the Atlantic overall, but almost all of them reached hurricane strength. Only two of the named storms did not strengthen to hurricanes, which hasn't happened in over 25 years. The 8 named storms of this season were in total more powerful than the total strength of all 14 of the named storms that occurred during the previous hurricane season.

In summary, the Atlantic Hurricane Season was less active than usual, but three storms had some impact on Newfoundland, and one of them, Hurricane Gonzalo, was stronger than average, especially in comparison to last year. AMEC's seasonal outlook verified exceptionally well. The season became dramatically more active near the end as conditions became more favourable for hurricane development. The storms did not generally head for the US seaboard

but were driven toward Atlantic Canada by other strong low pressure systems, a trend which has been occurring for the past few years and has the potential to continue or worsen in the years to come.

4. ADDITIONAL RESOURCES

More information on the Atlantic Hurricane Season can be found from these agencies:

Canadian Hurricane Centre: <http://www.ec.gc.ca/ouragans-hurricanes/>

United States National Hurricane Center: <http://www.nhc.noaa.gov/>

Department of Space and Climate Physics, University College London: <http://tropicalstormrisk.com/>

Department of Atmospheric Science, Colorado State: <http://hurricane.atmos.colostate.edu>