2018 Hurricane Briefing for the Institute for Catastrophic Loss Reduction

Bob Robichaud
Warning Preparedness Meteorologist
Canadian Hurricane Centre
Contents

• Tropical Cyclones 101
• Review of the 2017 Hurricane Season
• Outlook for the 2018 Hurricane Season
• Sources of information for monitoring hurricanes
Tropical Cyclones 101
Tropical Cyclones

- Tropical cyclone is the generic term for such storms as hurricanes, tropical storms, typhoons, etc.

- They form over the warm tropical waters around the world

- Tropical cyclones serve the purpose of redistributing energy stored in the ocean into the atmosphere
Hurricane Climatology

Hurricane Origin and Track by Month

June

July

August

September

October

November
Checklist for tropical cyclone formation

- Warm ocean waters that is sufficiently deep
- Unstable atmosphere
- High humidity in the lower levels of the atmosphere
- A minimum distance of at least 500 km from the equator
- A pre-existing near-surface disturbance
- Low wind shear
Tropical Cyclone – Nature’s Heat Engine
## Tropical Cyclone Classification

<table>
<thead>
<tr>
<th>Tropical Storm</th>
<th>Category 1</th>
<th>Category 2</th>
<th>Category 3</th>
<th>Category 4</th>
<th>Category 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind &gt; 63 km/h</td>
<td>119-153 km/h</td>
<td>154-177 km/h</td>
<td>178-208 km/h</td>
<td>209-251 km/h</td>
<td>Wind &gt; 252 km/h</td>
</tr>
</tbody>
</table>

**Tropical Cyclone Categories**

- **Category 1:** Minimal Damage
- **Category 2:** Some Damage
- **Category 3:** Extensive Damage
- **Category 4:** Devastating Damage
- **Category 5:** Catastrophic Damage
Tropical vs. Non-Tropical Storms

**Tropical Cyclone**
- Fueled by the warm water
- Slow-moving
- Symmetrical

**Non-Tropical Cyclone**
- Fueled by the horizontal contrast in air temperature
- Generally faster-moving
- Asymmetric

Major Hurricane Irma 2017

Winter Storm January 2018
Wind
Heavy rain
Strongest winds

Storm forms off Africa

Storm starts to speed up and curve northward

Storm size increases, rain begins to shift left of track

Strengthens to a hurricane, moves slowly westward

Storm becomes post-tropical, moving very fast, heavy rain on the left, strongest winds on the right

From Tropical to Post-Tropical
Tropical Cyclone Hazards

Summary of Tropical Cyclone Hazards in Canada

- Typical location of the heaviest rainfall
- Typical location of the highest storm surge
- Typical location of the highest waves
- Typical location of the strongest winds
Hurricane Season 2017 in Review
## 2017 Hurricane Season

### 2017 Atlantic Tropical Cyclone Season Review

<table>
<thead>
<tr>
<th></th>
<th>Predicted</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Named Storms:</td>
<td>11-17</td>
<td>17</td>
</tr>
<tr>
<td>Hurricanes:</td>
<td>5-9</td>
<td>10</td>
</tr>
<tr>
<td>Major Hurricanes:</td>
<td>2-4</td>
<td>6</td>
</tr>
</tbody>
</table>

- **Arlene**
- **Bret**
- **Cindy**
- **Don**
- **Emily**
- **Franklin**
- **Gert**

- **Harvey** (Retired)
- **Irma** (Retired)
- **Jose**
- **Katia**
- **Lee**
- **Maria** (Retired)
- **Nate** (Retired)

- **Ophelia**
- **Philippe**
- **Rina**
- **Sean**
- **Tammy**
- **Vince**
- **Whitney**
2017 Hurricane Season Storm Tracks

U.S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE
NORTH ATLANTIC HURRICANE TRACKING CHART

LAMBERT CONFORMAL CONIC PROJECTION
STANDARD PARALLELS AT 30 AND 60 SCALE OF NAUTICAL MILE

Environment and Climate Change Canada
Environnement et Changement climatique Canada
2017 Hurricane Season Storm Tracks

Canadian Hurricane Centre (CHC)
Centre canadien de prévisions des ouragans (CCPO)

- Storms of tropical origin affecting Canadian territory.
- Tempêtes d'origine tropicale affectant le territoire canadien.

2017

Legend / Légende
- Tropical Depression
- Dépression tropicale
- Tropical Storm
- Tempête tropicale
- Hurricane
- Ouragan
- Post-Tropical Storm
- Tempête post-tropicale
Early start to hurricane season

- First storm of the season was TS Arlene which formed on April 19th

- TS Bret and Cindy formed in June – no impact from Bret but Cindy resulted in 2 fatalities

- TS Don and Emily formed in July – no impact from Don but Emily resulted in flooding in southern part of Florida

- In early August, Franklin became the first hurricane of 2017 although was short-lived and impacts were minimal

- Hurricane Gert formed in mid August but stayed offshore (Cat 2)
Hurricane Harvey

- Harvey started as a typical weak August tropical storm that affected the Lesser Antilles
- After some weakening Harvey began to re-intensify after crossing the Yucatan
- Harvey rapidly intensified into a category 4 August 25th making landfall along the middle Texas coast
- Persistent heavy rains caused catastrophic flooding, and Harvey is the second-most costly hurricane in U.S. history, after accounting for inflation, behind only Katrina (2005)
Hurricane Harvey

- Landfall along the Texas Gulf Coast late on August 25th as a Cat 4
- First Major Hurricane to make landfall in the U.S. since 2005
- Peak recorded wind speed of 229 km/h
- 57 reported tornadoes with Harvey
- Significant storm surge was also reported (as high as 2-3 m)
Hurricane Harvey

• Very slow movement of the storm over the next few days resulted in extreme rainfall

• Harvey was the most significant tropical cyclone rainfall event in United States history

• The highest storm total rainfall report from Harvey was 1539 mm

• Radar estimates indicated that the peak rainfall could be in the 1600 to 1800 mm range

• The rainfall was also extreme in areal coverage
Hurricane Harvey

Hurricane Harvey Rainfall Comparisons

- Harvey maximum rainfall: 1800 millimetres
- Annual rainfall Toronto
- Calgary Flood 2013
- Hurricane Beth 1971
- Cape Breton Floods 2016
- Toronto Flood 2013
Hurricane Harvey - Impacts

- At least 68 people died from the direct effects of the storm in Texas
- Over 300,000 structures were flooded
- Up to 500,000 cars were flooded
- 40,000 people evacuated or took refuge
- About 30,000 water rescues were reported
- 336,000 customers lost power
- Oil refineries were shut down for extended periods
Hurricane Harvey - Impacts

- About 75% of the flood damage occurred OUTSIDE the 100-year flood zone
- 80% of flood victims DID NOT have flood insurance
- Preliminary estimates for damage costs are at $125 B U.S.
- Recovery continues
Hurricane Irma

- Developed off the coast of Africa in late August and became a hurricane early on August 31st

- Eventually reached Cat 5 with winds of 290 km/h

- Landfall in Barbuda and St Martin at peak intensity

- Two more landfalls as Cat 5 – British Virgin Islands, Cuba and one as Cat 4 in Bahamas
Hurricane Irma

- Irma made its 6th landfall in the Lower Florida Keys on September 10th as a Cat 4 Hurricane

- Final landfall was near Marco Island before the storm crossed the spine of Florida

- Peak wind was 257 km/h (unofficial report of 320 km/h)

- Peak wind in the U.S. was 193 km/h in the Florida Keys

- 21 tornadoes were reported
Hurricane Irma

- Positive storm surge was reported at several location in the Caribbean and in the U.S.
- Offshore winds on the northern side of Irma’s circulation initially caused a negative storm surge and receding water levels along Florida’s West Coast
- Some normally submerged areas went virtually dry, allowing people to walk out onto the sea or bay floor
- This is a very dangerous situation as the water will eventually rise and rise rapidly
Hurricane Irma - Impacts

• 129 fatalities, 44 direct and 85 indirect
• About $50 B U.S. in damages
• Widespread devastation in the Caribbean
• Total destruction on the island of Barbuda
• Entire island was left the island – totally uninhabited for the first time in 300 years
• 150,000 homes damaged in Cuba
• Lower Florida Keys were devastated
Hurricane Irma - Impacts

- Largest evacuation in U.S. history (6.8 Million)
- Significant flooding along the east coast of Florida
- Combination of storm surge and heavy rain resulted in worst flooding in Jacksonville in over 225 years
- Wind impacts extended into Georgia and the Carolinas
- Extreme focus on the track resulted in some misinterpretation of the forecast for Florida
Hurricane Season 2017 Continues

- Jose formed in early September and intensified rapidly to Cat 4 then meandered off the coast of New England for a few days.

- Katia was a short-live Cat 2 hurricane that formed in the Gulf of Mexico.

- Lee formed in mid-September and reached Cat 3 but stayed offshore.
Hurricane Maria

- Maria also formed over the central Atlantic in mid-September

- Rapidly intensified to a major hurricane eventually reaching Cat 5 with winds 282 km/h

- Ravaged the island of Dominica with winds of 269 km/h

- Direct hit on Puerto Rico with winds of 250 km/h

- Approached Carolina coast before making a hard right turn
Hurricane Maria - Impacts

- 112 fatalities direct fatalities, likely well over 1,000 indirect fatalities so far
- Dominica sustained catastrophic damage
- $90 billion USD in damage (3rd costliest hurricane in U.S. history)
- Electric grid was devastated (80% of utility poles were destroyed)
- Practically all cell phone service was lost and municipal water supplies were knocked out
- Recovery still very much ongoing today
Hurricane Nate

- Nate was a Cat 1 Hurricane that formed in early October and impacted Central America and the U.S. Gulf Coast
- Close to 500 mm of rain reported in Central America
- 44 fatalities
- Flooding and mudslides in Costa Rica
- Heavy rain, flooding and storm surge were reported in the U.S.
- About $800 million in damage
Hurricane Season 2017 Continues

- Ophelia was a storm that formed in mid-October and became the final hurricane of 2017.
- Ophelia reached Cat 3 and followed an odd track that brought it into Europe as a strong Post-Tropical Storm.
- Phillip was a late October TS – minimal impacts.
- Finally Rina formed in early November. With Rina, 2017 became the only season with a named storm in every month.
2017 Hurricane Season Summary

• 2017 was an historic season with several new records set during the season – 7th most active year in the last 167 years

• 6 major hurricanes formed in 2017, the most since the hyperactive 2005 season

• Costliest year for hurricanes – $265 Billion

• 2nd (Harvey), 3rd (Irma) and 5th (Maria) costliest U.S hurricanes

• Five Category 5 landfalls

• Three Category 4 landfalls in the U.S in 26 days – only three in the previous 56 years!!

• First time the U.S. had two landfalling category 4 hurricanes the same year – Harvey and Irma

• Harvey set a new record for tropical cyclone-generated rainfall in the U.S. with 1539 mm
2017 Hurricane Season Summary

- 37 cases of rapid intensification (strengthening of the wind speed by at least 55 km/h in 24 hours) in 2017 – only 6 were correctly forecast by NHC

- Ophelia was the farthest east that an Atlantic major hurricane had ever been observed
Canadian Hurricane Centre

Hurricane Season Outlook 2018
Factors Influencing Hurricane Season

- Water Temperature
- Wind Shear
- Multi-decadal cycle

Less active - Average - More active
Current Water Temperature

MW + IR OI v5.0 Sea Surface Temperature: 2018-05-17 - Atlantic, North

Remote Sensing Systems
www.remss.com

Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canada
Latest Atlantic Sea Surface Temperature Pattern

Water temperatures are warmer than normal

Water temperatures are cooler than normal
Factors Influencing Hurricane Season

Water Temperature

Wind Shear

Multi-decadal cycle

Less active

Average

More active
Factors Affecting Hurricane Season

May 30, 2017

Global sea surface anomaly and snow cover
30 May 2017

Anomalie de la température de la mer et épaisseur de la neige
30 Mai 2017

Sea surface temperature anomaly / Anomalie de la température de la mer (°C)

Uncovered sea ice
Glace marine à découvert
Climatologie 1995-2009 Climatology

CMC Environnement Canada
CMC Environment Canada
Factors Affecting Hurricane Season

Global sea surface anomaly and snow cover
31 May 2018

Anomalie de la température de la mer et épaisseur de la neige
31 Mai 2018

May 31, 2018

Sea surface temperature anomaly / Anomalie de la température de la mer (°C)

Uncovered sea ice
Glace marine à découvert

Climatologie 1995-2009 Climatology

CMC Environnement Canada

Snow depth / Épaisseur de la neige (cm)
El Niño forecast through hurricane season
Factors Influencing Hurricane Season

Water Temperature

Wind Shear

Multi-decadal cycle

Less active

Average

More active

Canada
2018 Hurricane Season Outlook

2018 NOAA Hurricane Season Outlook

Season Probability

- Below Normal: 35%
- Near Normal: 25%
- Above Normal: 40%

10-16 Named Storms
(Average 12)

5-9 Hurricanes
(Average 6)

1-4 Major Hurricanes
(Average 2)
Based on the 30 year average, about 35-40% of the named storm that for in the Atlantic enter the CHC Response Zone.
List of Atlantic Storm Names

2018 Tropical Cyclone Names

- Alberto
- Beryl
- Chris
- Debby
- Ernesto
- Florence
- Gordon
- Helene
- Isaac
- Joyce
- Kirk
- Leslie
- Michael
- Nadine
- Oscar
- Patty
- Rafael
- Sara
- Tony
- Valerie
- William
Operational Response to Approaching Storms: Hurricane monitoring tools
Hurricane Forecast Centres

NHC is the Regional Specialized Meteorological Center (RSMC) for the WMO RA-IV

CHC provides Canadians with meteorological information on hurricanes, tropical storms and post-tropical storms

Detailed information from CHC starts about 72 hours BEFORE the storm crosses this line
Hurricane Weather Products - NHC

Graphical Tropical Weather Outlook

<table>
<thead>
<tr>
<th>Categories</th>
<th>Probability of formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt; 40%</td>
</tr>
<tr>
<td>Medium</td>
<td>40-60%</td>
</tr>
<tr>
<td>High</td>
<td>&gt;60%</td>
</tr>
</tbody>
</table>

- Track map with range of possible tracks (cone)
- Wind speed probability map
- Wind history
- Time of arrival of tropical storm force winds
- Surge and rainfall maps
- Key messages graphic

https://www.nhc.noaa.gov/
Hurricane Weather Products - CHC

www.hurricanes.ca

Hurricane Track Maps
- All tracks will be displayed on the CHC hurricane track map
  - Blue tracks are CHC-issued tracks
  - Red tracks are NHC-issued tracks

Bulletin Structure
1) Summary information on initial position, intensity, motion
2) Public impacts
   • warnings broken down by hazard (wind, rainfall, surge/waves)
3) Marine impacts and warning
Hurricane Weather Products

> 5 Day
- Tropical Weather Outlook
- NHC Track and Intensity Forecasts
- NHC Windspeed Probability Maps Time of Arrival Maps
- CHC Preliminary Discussion

3-5 Days
- CHC Track map and Information Statements
- NHC Windspeed Probability Maps Time of Arrival Maps

2-3 Days
- CHC Track map and Information Statements
- NHC Windspeed Probability Maps
- Time of Arrival Maps
- Watches and Warnings
- Official ECCC Forecasts

1-2 Days

<table>
<thead>
<tr>
<th>Categories</th>
<th>Probability of formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt; 40%</td>
</tr>
<tr>
<td>Medium</td>
<td>40-60%</td>
</tr>
<tr>
<td>High</td>
<td>&gt;60%</td>
</tr>
</tbody>
</table>
Forecast Uncertainty – Track Error

- Cone of uncertainty is constructed by superimposing position error at each forecast time
- You must assume that the centre of the storm will track ANYWHERE within that cone
- There is also a 33% chance the storm could track outside the cone
- Keep in mind that impacts could extend well outside the cone

2018 Position Errors

<table>
<thead>
<tr>
<th>Time (hrs)</th>
<th>Error (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>367</td>
</tr>
<tr>
<td>96</td>
<td>280</td>
</tr>
<tr>
<td>72</td>
<td>191</td>
</tr>
<tr>
<td>48</td>
<td>137</td>
</tr>
<tr>
<td>24</td>
<td>80</td>
</tr>
<tr>
<td>12</td>
<td>48</td>
</tr>
</tbody>
</table>
....it only takes one storm to make it a bad year!