2016 Hurricane Briefing for the Institute for Catastrophic Loss Reduction

Bob Robichaud
Warning Preparedness Meteorologist
Canadian Hurricane Centre
Contents

- The 5 Ws of Tropical Cyclones
- Tropical Cyclone Hazards
- Review of the 2015 Hurricane Season
- Outlook for the 2016 Hurricane Season
- Operational Response to Approaching Storms: Forecasting and Communications
Who...

...issues forecasts for tropical cyclones?
Who issues forecasts for Tropical Cyclones?

- NHC is one of 7 RSMCs that produce and coordinate tropical cyclone forecasts for various ocean basins.
- NHC is responsible for both the Atlantic and eastern North Pacific Ocean basins.
Who issues forecasts for Tropical Cyclones?

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
What...
Tropical Cyclones

- Tropical cyclones are relatively large and long-lasting low pressure systems that form over warm water.

- Tropical cyclones must have a closed surface wind circulation around a well-defined center.

- They are classified by maximum sustained surface wind speed.
Tropical Cyclone Classification

Tropical Disturbance
Wind < 37 km/h (23 mph)

Tropical Depression
Wind 37+ km/h (23 mph)

Tropical Storm
Wind 63+ km/h (39 mph)

Hurricane – Cat. 1
Wind 118+ km/h (74 mph)

Hurricane – Cat. 2
Wind 154+ km/h (96 mph)

Hurricane – Cat. 3
Wind 178+ km/h (111 mph)

Major Hurricane
Wind 211+ km/h (131 mph)

Hurricane – Cat. 4

Major Hurricane

Hurricane – Cat. 5

Major Hurricane

Wind > 251 km/h (156 mph)
Tropical Cyclones – Nature’s Heat Engine

Air flows outwardly from the center, in the cooler upper levels of the storm.

The warm, humid air rises rapidly in thunderstorm updrafts near the center.

Winds near the surface carry warm, moist air in towards the storm center.

Eye
Eyewall

Rainbands

Evaporation from the warm ocean surface supplies the storm's fuel.

The COMET Program
Tropical vs. Post-Tropical

**Tropical**
- Stronger winds for a series of concentric bands around the centre of the storm
- Strongest winds are found in the band closest to the centre – this is called the eyewall
- Rain is heavy and fairly symmetric around the centre of the storm

**Post-Tropical**
- Size of the storm increases
- Strongest winds usually found on the right side of the storm’s track and some distance away from the centre
- Heaviest rain usually found on the left side of the storm’s track
When...

...do tropical cyclones form?
Tropical Cyclone Climatology

Number of North Atlantic Basin Tropical Cyclones per 100 Years

- Depressions + Storms + Hurricanes + Major Hurricanes
- Storms + Hurricanes + Major Hurricanes
- Hurricanes + Major Hurricanes
- Major Hurricanes

Tropical Cyclone distribution by month

Start of Hurricane Season

End of Hurricane Season
Where...

...do tropical cyclones form?
Climatological Areas of Origin of Tropical Cyclones
Why...

...do tropical cyclones form?
Why do they form?

- Tropical Cyclones form due to a build-up of heat energy in the ocean.
- The purpose of a Tropical cyclone is to regulate the planet’s temperature.
Tropical Cyclone Hazards
## Tropical Cyclone Hazards - Wind

### Saffir-Simpson Scale for Hurricanes

<table>
<thead>
<tr>
<th>Category</th>
<th>Wind Speed (km/h)</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>119 - 153</td>
<td>Very dangerous winds will produce some damage</td>
</tr>
<tr>
<td>2</td>
<td>154 - 177</td>
<td>Extremely dangerous winds will cause extensive damage</td>
</tr>
<tr>
<td>3</td>
<td>178 - 208</td>
<td>Devastating damage will occur</td>
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<tr>
<td>4</td>
<td>211 - 249</td>
<td>Catastrophic damage will occur</td>
</tr>
<tr>
<td>5</td>
<td>&gt;249</td>
<td>Catastrophic damage will occur</td>
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</table>

- Winds are strong on both sides of a hurricane
- When a storm becomes post-tropical:
  - Storm size increases
  - Speed of the storm increases
  - Difference in wind speed between right and left side of the track increases
- Sometimes a post-tropical storm can interact with a trough and produce strong winds on both sides
Storm maximum wind location for storms entering the CHC Response Zone.

(Location by quadrant of occurrence)
Factors affecting rainfall amounts and distribution in tropical cyclones

1. **Size**  (bigger storm = more rain)
2. **Motion**  (slower storm = more rain)
3. **Rain rate**  (higher rain rate = more rain)
4. **Duration**  (longer duration = more rain)
5. **Stage of transition to post-tropical**

Tropical systems by their very nature produce extreme rainfall rates (rates can reach 20-50 mm per hour)

As tropical cyclones become post-tropical the heaviest rain migrates to the left side of the storm track

Sometimes narrow bands of concentrated moisture originating from the tropics can cause extreme rainfall

These “Atmospheric Rivers” can extent 1000s of km from a tropical cyclone and cause significant flooding even though the actual storm is far away

Atmospheric River extending from Hurricane Tomas in 2010
Storm Surge

- Abnormal rise in water generated by a storm, over and above the astronomical tide
- Caused primarily by force of wind blowing across water surface
- Contribution by low pressure within center of storm is minimal

Some Factors Affecting Storm Surge:
- Wind speed
- Direction of the storm
- Size of the storm
- Coastal bathymetry
Tropical Cyclone Hazards - Waves

Damaging Waves

• On occasion a particular phenomenon can give rise to extreme wave heights
• Waves move in harmony with a storm, allowing waves to build to enormous heights
• This threat is most significant along the Atlantic coast

- **Hurricane:** Slow-moving storm, waves move out ahead of storm
- **Winter storm:** Fast-moving storm, large waves lag behind the storm
- **Post-tropical storm:** Accelerating storm, waves/storm in sync, waves build to extreme heights
Hurricane Season 2015 in Review
## What happened last year?

<table>
<thead>
<tr>
<th></th>
<th>Named Storms</th>
<th>Hurricanes Category 1 to 5</th>
<th>Major Hurricanes Category 3-5</th>
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</thead>
<tbody>
<tr>
<td>National Oceanic and Atmospheric Administration (US)</td>
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<td>3-6</td>
<td>0-2</td>
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<tr>
<td>Actual storms in 2015</td>
<td>11</td>
<td>4</td>
<td>2</td>
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<tr>
<td>1981-2010 Average</td>
<td>12</td>
<td>6</td>
<td>2 or 3</td>
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</tbody>
</table>
2015 Season in Review
2015 Season in Review

2015 season activity:

• 4 storms entered CHC response zone
• Average is also about 4
2015 Season in Review – Ana

- Formed in early May and became a tropical storm
- Presented some forecasting challenges but no impacts on Canada
2015 Season in Review – Claudette

- Formed off the coast of SC on July 12th then became a tropical storm
- Moved northeastward over the next few days
- Produced locally heavy showers in Newfoundland and Labrador but otherwise little impact
2015 Season in Review – Henri

- Became a tropical storm September 8th over the open ocean
- Maximum winds reached 90 km/h followed by rapid weakening
- No significant impacts in Canada
2015 Season in Review – Joaquin

• Became a tropical storm September 28th
• Reached hurricane September 30th and went from Cat 1 to Cat 3 in 12 hours
• Some swell reached NS and NL but no significant impacts
Hurricane Joaquin – Indirect impacts

• Well after the threat of Joaquin making landfall in the U.S. or Canada had passed, a stalled weather system over the Southeast U.S. entrained some moisture from Joaquin.

• This second system was also associated with the one that resulted in 200+ mm of rain in New Brunswick on October 1st.

• The combination of these two events resulted in a very heavy rainfall over the Southeast.

• South Carolina was particularly hard-hit as what occurred there has been characterized as a 1 in 1000 year rainfall event.
Hurricane Joaquin – Indirect Impacts

• Peak rainfall amounts recorded were 722 mm near Charleston SC

• Equivalent of 11 trillion gallons of water fell on Charleston in 3 days

• Record flooding event for South Carolina

• State EOC was activated from October 1st to October 23rd
Hurricane Joaquin – Indirect Impacts

- Storm related fatalities: 19
- Displaced citizens: Over 20,000
- Shelters: 32
- Emergency meals served: 2.7M
- People without water: 40,000
- Collisions during the event: 3,521
- Dam failures: 36
- Roads and bridges closed: 500+
- Water rescues: Over 1,500
- Calls taken by the Public Information phone System: 12,900+
2016 Hurricane Season Outlook
# 2016 Hurricane Season Outlook

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<td>1961-2010 Average</td>
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Factors Affecting the 2016 Hurricane Season

December 2015

Global sea surface anomaly and snow cover
09 Dec 2015

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

Uncovered sea ice
Glace marine à découvert

Climatologie 1995-2009 Climatology

CMC Environment Canada
Factors Affecting the 2016 Hurricane Season

Global sea surface anomaly and snow cover
30 May 2016

Anomalie de la température de la mer et épaisseur de la neige
30 Mai 2016

May 30th 2016

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 Environnement Canada
El Niño forecast through hurricane season

Mid-May 2016 Plume of Model ENSO Predictions

Dynamical Model:
- NASA GMAO
- NCEP CFSv2
- JMA
- SCRIPPS
- LDEO
- AUS/POAMA
- ECMWF
- UKMO
- KMA SNU
- IOCAS ICM
- COLA CCSM4
- MetFRANCE
- SINTEX-F
- CS-IRI-MM
- GFDL CM2.1
- CMC CANSIP
- GFDL FLOR

Statistical Model:
- CPC MRKOV
- CDC LIM
- CPC CA
- CPC CCA
- CSU CLIPR
- UBC NNET
- FSU REGR
- UCLA-TCD
- UNB/CWC
## List of Atlantic Storm Names

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<th>Alex</th>
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Hurricane Readiness and Operational Response to Hurricanes
# Hurricane Weather Products

## Tools for Monitoring Tropical Cyclone Activity

<table>
<thead>
<tr>
<th>National Hurricane Centre Tropical Weather Outlook</th>
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<tbody>
<tr>
<td>National Hurricane Centre Track and Intensity Forecast</td>
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<tr>
<td>National Hurricane Centre Wind Probability Maps</td>
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<tr>
<td>Canadian Hurricane Centre Track and Intensity Forecast</td>
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<tr>
<td>Canadian Hurricane Center Watches</td>
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<tr>
<td>Storm Prediction Centre Warnings</td>
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<td>Official Forecasts</td>
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<thead>
<tr>
<th>Time Frame</th>
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<td>T-72</td>
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<td>36hrs 122 km</td>
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<td>T-6</td>
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The above is a suggested list of weather information tools to use for monitoring tropical cyclones in the Atlantic as they approach Canada.
Hurricane Weather Products

Monitoring Storm Formation Potential
A good tool to check overall tropical activity is the Tropical Weather Outlook issued by the NHC

www.nhc.noaa.gov/gtwo_atl.shtml

<table>
<thead>
<tr>
<th>Categories</th>
<th>Probability of formation</th>
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<tbody>
<tr>
<td>Low</td>
<td>&lt; 40%</td>
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<tr>
<td>Medium</td>
<td>40-60%</td>
</tr>
<tr>
<td>High</td>
<td>&gt;60%</td>
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Monitoring Individual Storms
Details on storms that are not an imminent threat to Canada can be found on the National Hurricane Centre Website:

www.nhc.noaa.gov

Monitoring Individual Storms
Details on storms are expected to have an impact in Canada can be found on the Canadian Hurricane Centre Website:

www.hurricanes.ca
Hurricane Weather Products – 36 hrs or less

Watches and Warnings

- Once the storm is close enough and forecast confidence is higher watches and warnings are issued in addition to the information bulletins

**Tropical Storm**: winds 70 km/h to 118 km/h

**Hurricane**: winds 119 km/h or more

A Watch lets you know conditions are favourable for the hazard to occur within 36 hours

A Warning requires immediate action as the hazard is occurring or is likely to occur within 24 hours

Note: It is recommended that all storm preparation activities be complete prior to the arrival of Tropical Storm Force winds
Operational Response to Hurricanes

Key Messages

• The CHC will continue to try and increase our activity on social media

• A TweetChat is being planned for some time during the hurricane season

• The CHC is also planning on adopting the “key messages” approach in the bulletins

• Key messages can easily adapted for social media
Hurricane Season 2016 Outlook

• The numbers of tropical storms and hurricanes are expected to be near or slightly above normal

• One of the key weather patterns that reduces hurricane activity in the Atlantic, El Nino, is not expected to be a factor this year

• There are some theories that would suggest more of the 2016 hurricane season storms will develop in the Caribbean or western Atlantic rather than off the coast of Africa

• If this season is near normal, it would be the 4th year in a row with near average or below average
....it only takes one storm to make it a bad year!