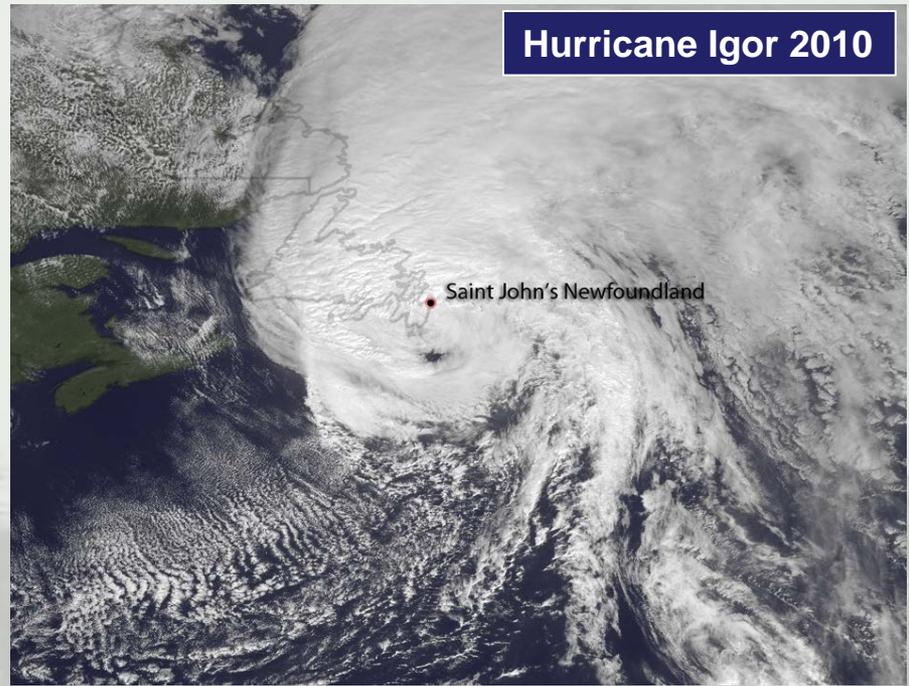
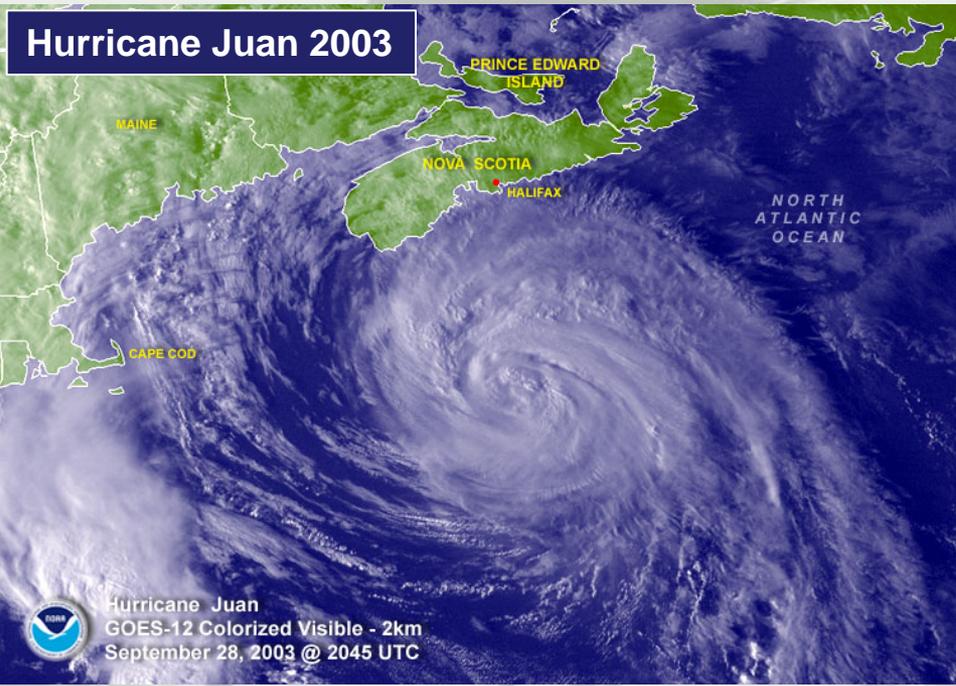


Enhancements in NHC and CHC Forecast Products that have Assisted in More Effective Communication of Hurricane Risk and Forecast Uncertainty



Daniel P. Brown & Jack Beven
National Hurricane Center, Miami, FL



Chris Fogarty
Canadian Hurricane Center, Halifax, NS



National Hurricane Center Miami, FL

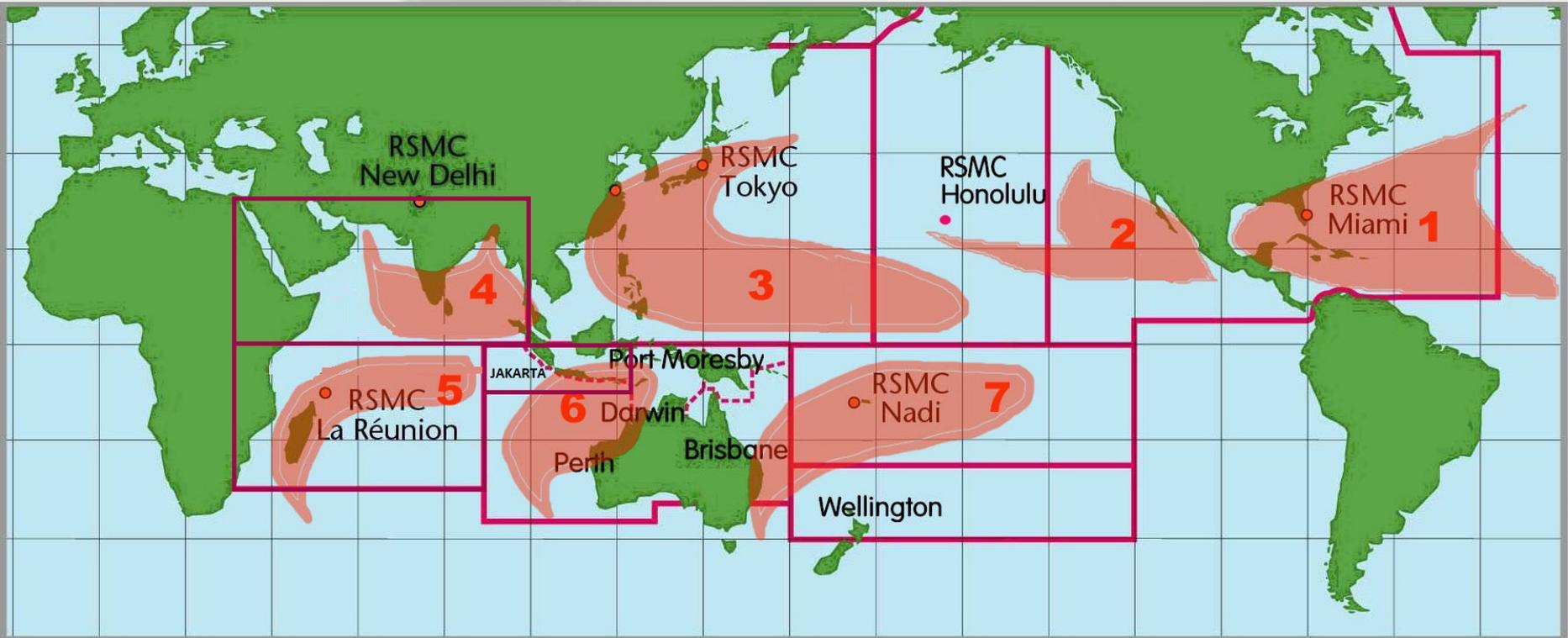


- **“National Hurricane Center” adopted for a part of the Miami Weather Forecast Office in 1955**
- **Located on or near the University of Miami in the 1960-1990s**
- **Moved into a better built facility in 1995 on the Campus of FIU**



World Meteorological Organization

Regional Specialized Meteorological Centers (RSMC)



- 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.



Major NHC Milestones



1955: Regularly scheduled numerical model forecasts began

1961: 2-day tropical cyclone forecasts introduced

1964: 3-day tropical cyclone forecasts began

1980: NHC begins issuing all Atlantic advisories

1988: NHC assumes responsibility for the E. Pacific

mid 1990s: NHC web site developed and graphics produced

2001: Cone graphic introduced

2003: 4-day and 5-day forecasts began

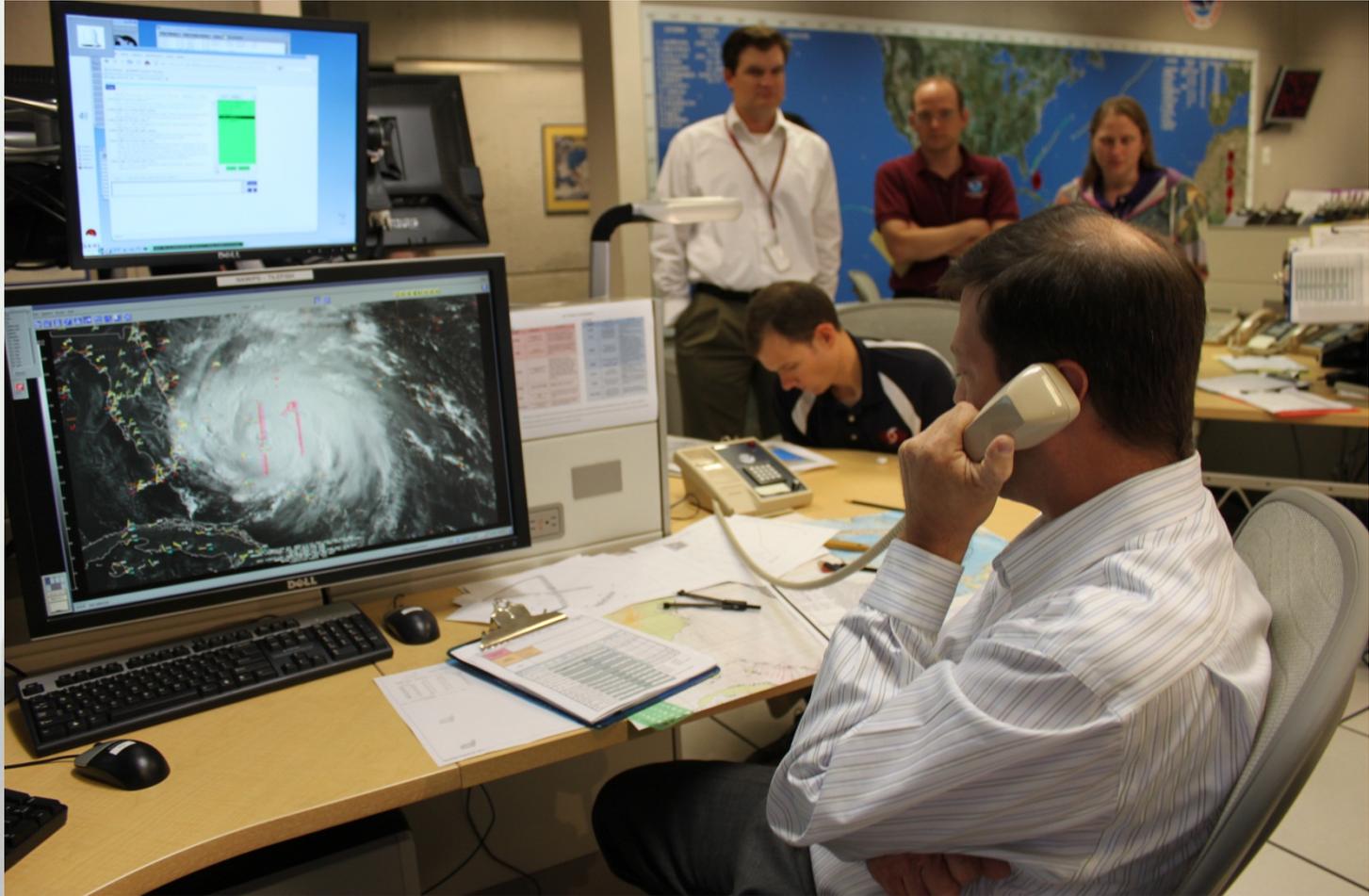
2007: Graphical Tropical Weather Outlook first issued

2010: Tropical cyclone watch/warning lead times increased

2013: Tropical Weather Outlook expanded from 48 h to 5 days



National Hurricane Center Operations & Warning Coordination





NHC Six-Hour Forecast Cycle



Time (HR : MIN)	Event
00:00	Issue Tropical Weather Outlook Issue Intermediate Public Advisory (if necessary) Synoptic time / cycle begins
00:30	Receive satellite fix data
00:45	Initialize models
01:00	Receive model guidance and <i>prepare forecast</i>
02:00	NWS / DOD hotline coordination <i>International Watch/Warning Coordination</i>
03:00	Advisory deadline
03:15	FEMA conference call
06:00	New cycle begins



NHC's International Coordination

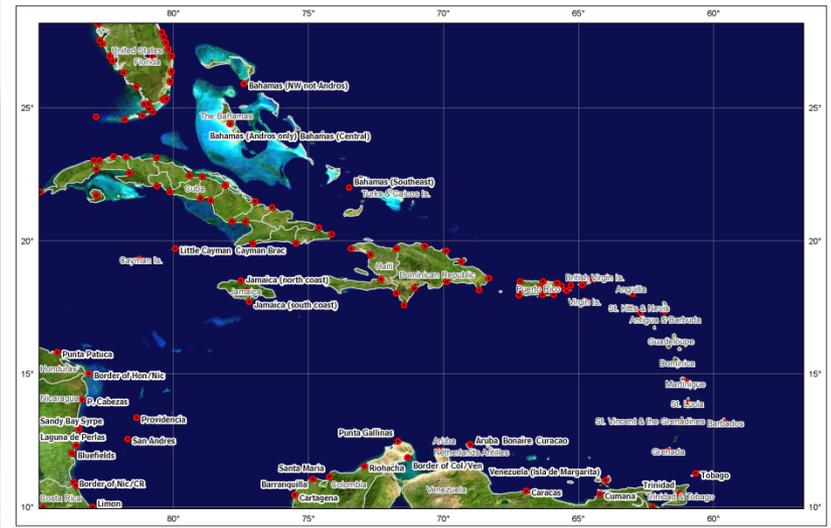
World Met. Organization - Regional Association IV Coordination





How NHC Coordinates International Watches & Warnings

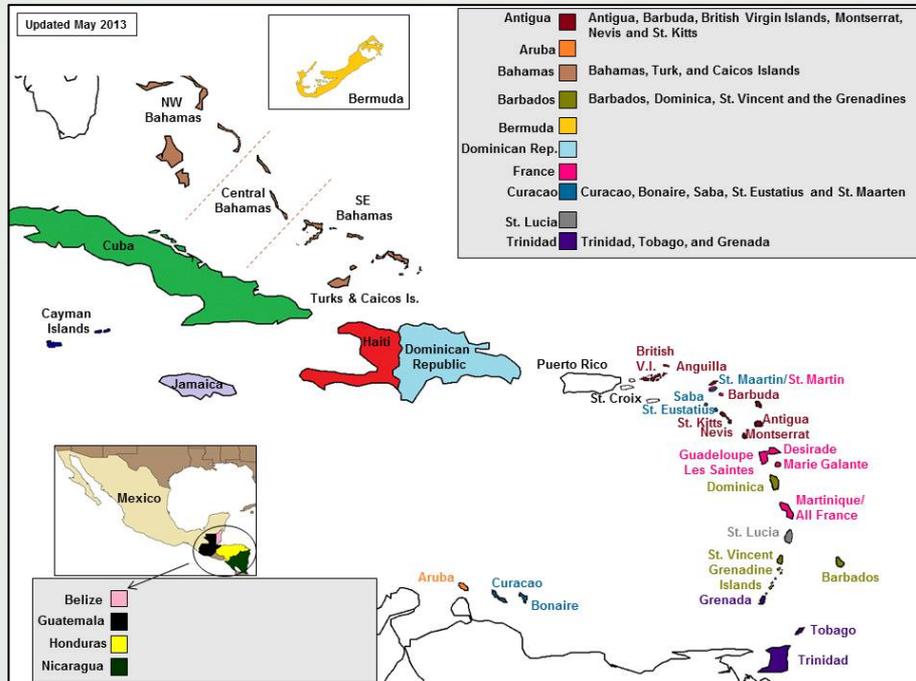
- Each country is responsible for issuing watches & warnings for their respective country or jurisdiction
- NHC will recommend the placement of watches & warnings
- Coordinated via phone with Met. Offices throughout the region
- Tropical Storm or Hurricane Watches and Warnings are currently not issued prior to the formation of a tropical depression



Tropical Cyclone Breakpoints - Caribbean



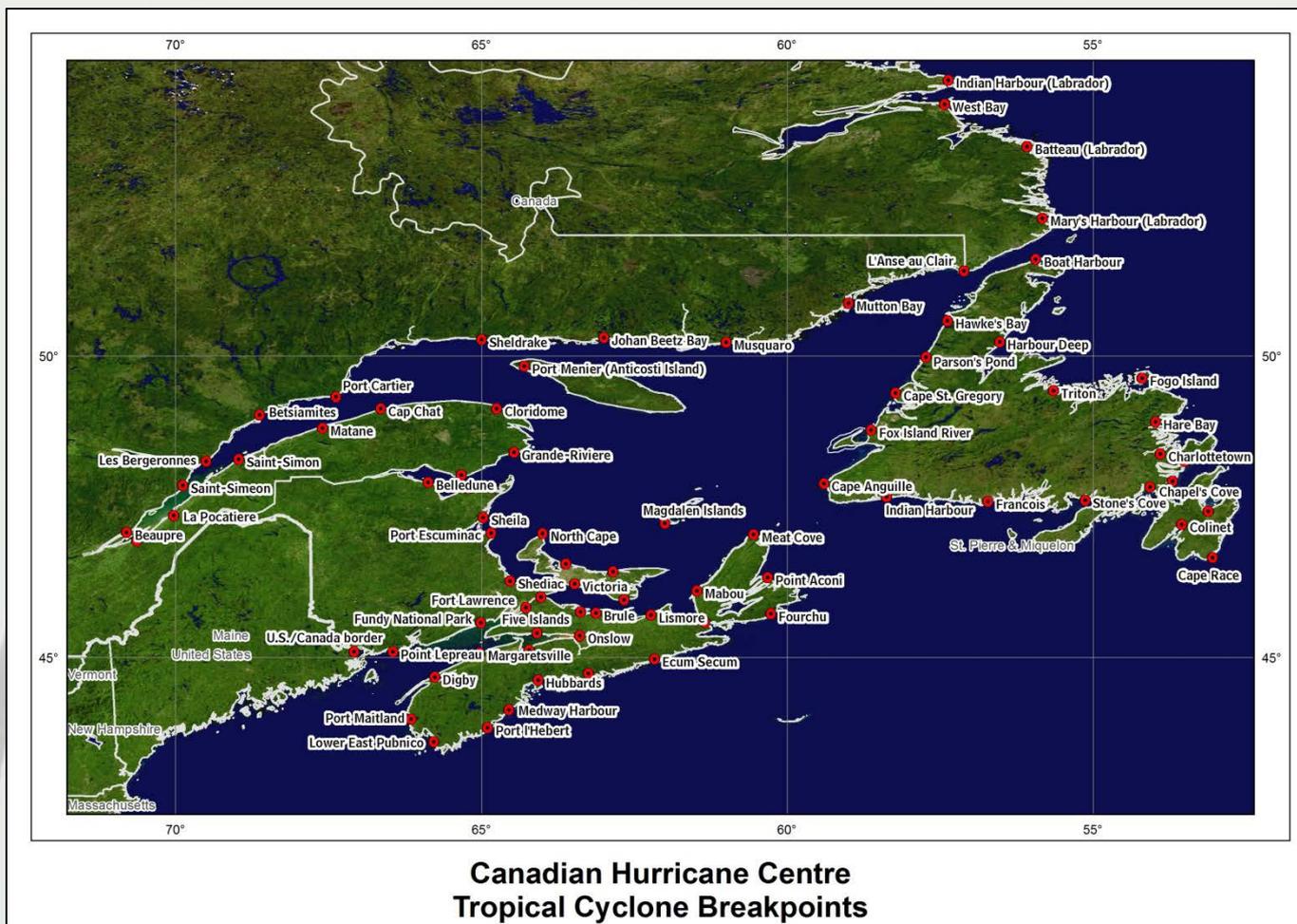
How NHC Coordinates International Watches & Warnings



- Watch/Warning coordination can be a very time consuming process
- May have to coordinate with several countries at once
- Language differences can increase coordination time/difficulties
- Forecaster on duty may not be the final decision maker for the country

Coordination with our Canadian counterparts is great!!!

Watches & Warnings are Coordinated via Coastal “Breakpoints”



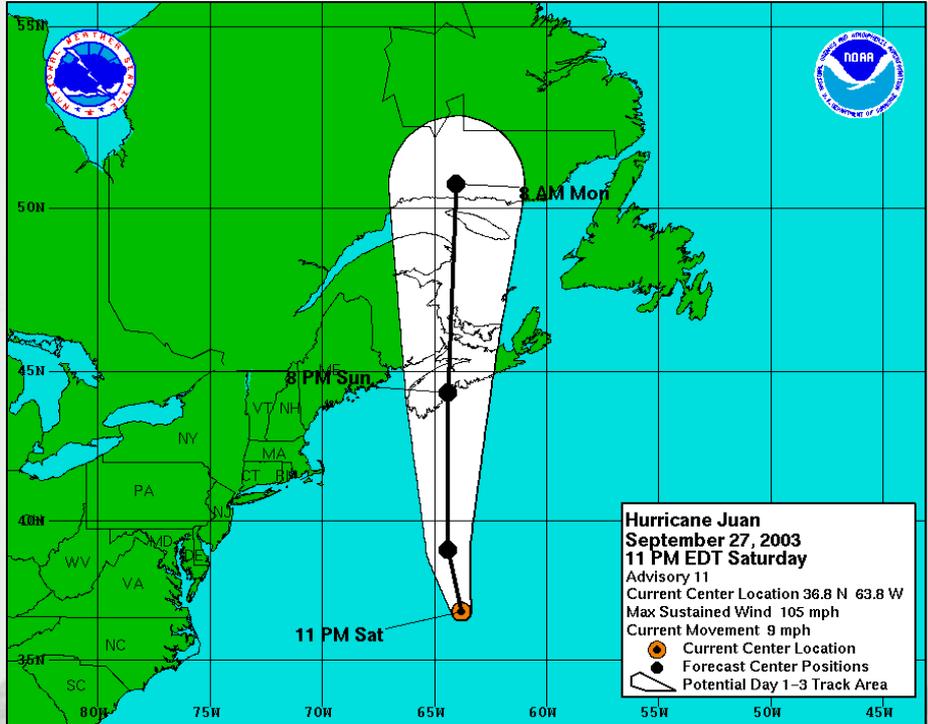
This has not always been the case with the Canadian Hurricane Center



How Warning Coordination has Evolved Between NHC and CHC



- Prior to Hurricane Juan (2003)- NHC coordinated TC forecasts with CHC, but Environment Canada issued warnings “independently”
- No watches/warnings shown on NHC graphics
- Warning text in NHC public advisory not very comprehensive
 - Rain & wind warnings mentioned
 - Hurricane-force wind warnings reference



```
ZCZC MIAATCPAT5 ALL
TTAA00 KNHC DDHMM
BULLETIN
HURRICANE JUAN ADVISORY NUMBER 11
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL
11 PM AST SAT SEP 27 2003

...JUAN MAINTAINING STRENGTH AS IT CONTINUES TOWARD NOVA SCOTIA...

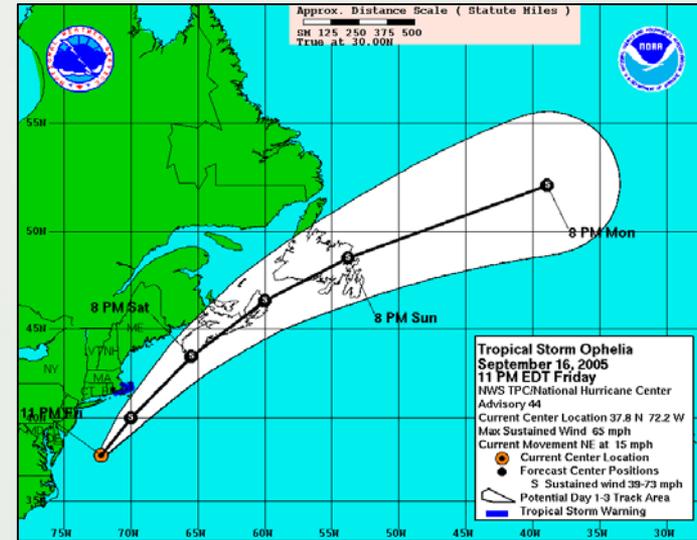
RAIN AND WIND WARNINGS CONTINUE IN EFFECT FOR NOVA SCOTIA. HURRICANE
FORCE WIND WARNINGS CONTINUE IN EFFECT FOR THE NOVA SCOTIA MARINE
AREAS.
```



How Warning Coordination has Evolved Between NHC and CHC



- By 2005, NHC & CHC coordinated specific tropical storm & hurricane watches and warnings
- Provided in NHC public advisory but not shown on NHC graphic products



```
ZCZC MIATCPAT1 ALL
TTAA00 KNHC DDHMM
BULLETIN
```

```
TROPICAL STORM OPHELIA ADVISORY NUMBER 44
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL
11 PM EDT FRI SEP 16 2005
```

```
...OPHELIA GRADUALLY ACCELERATING NORTHEASTWARD AS IT PARALLELS THE
NORTHEASTERN U.S. COAST...
...NEW WATCHES AND WARNINGS ISSUED FOR NOVA SCOTIA...
```

```
AT 11 PM EDT...0300Z...THE TROPICAL STORM WARNING WEST OF WESTPORT
MASSACHUSETTS HAS BEEN DISCONTINUED. A TROPICAL STORM WARNING IS
NOW IN EFFECT FOR SOUTHEASTERN MASSACHUSETTS FROM WESTPORT TO CAPE
COD TO PLYMOUTH...INCLUDING MARTHA'S VINEYARD AND NANTUCKET. A
TROPICAL STORM WARNING MEANS THAT TROPICAL STORM CONDITIONS ARE
EXPECTED IN THE WARNING AREA IN THE NEXT 24 HOURS.
```

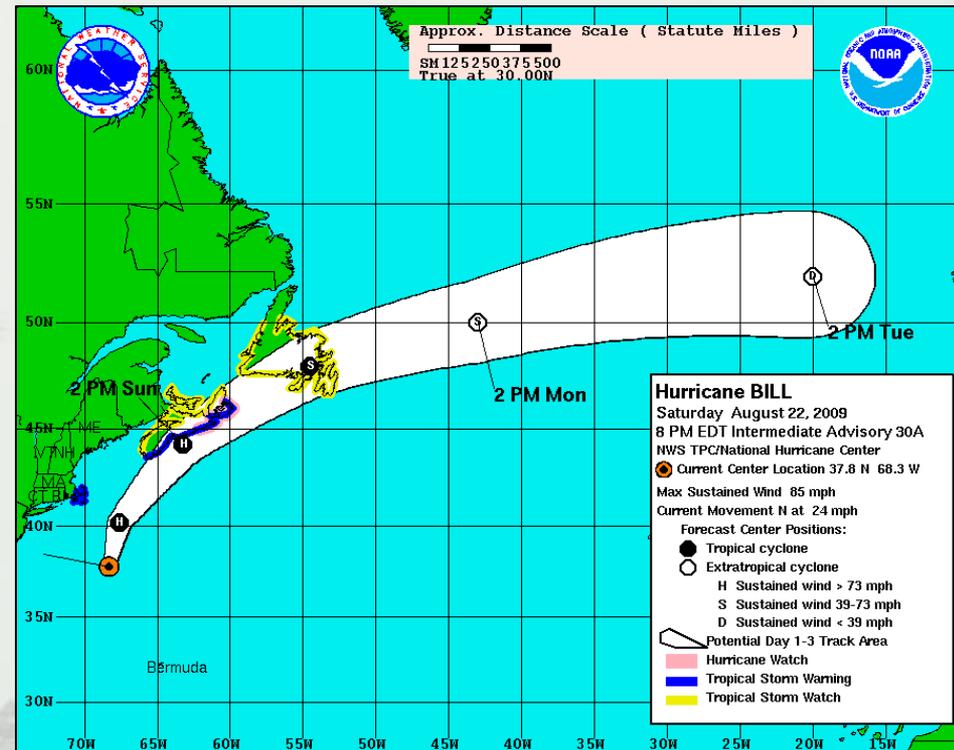
```
AT 11 PM AST...0300Z...THE CANADIAN HURRICANE CENTER HAS ISSUED A
TROPICAL STORM WARNING FOR PORTIONS OF SOUTHWESTERN NOVA SCOTIA
FROM YARMOUTH EASTWARD TO LUNENBURG. THE TROPICAL STORM WATCH AREA
HAS BEEN EXPANDED AND IS NOW IN EFFECT FROM TRURO WESTWARD TO NORTH
OF YARMOUTH...AND FROM EAST OF LUNENBURG EASTWARD TO SHEET HARBOUR.
A TROPICAL STORM WATCH MEANS THAT TROPICAL STORM CONDITIONS ARE
POSSIBLE WITHIN THE WATCH AREA...GENERALLY WITHIN 36 HOURS.
```



How Warning Coordination has Evolved Between NHC and CHC



- By 2009, NHC had the ability to display CHC tropical storm and hurricane watches and warnings on NHC graphics
- Coordination has become much more efficient with pre-defined breakpoints and procedures
- For transitioning systems, NHC and CHC would had to decide tropical or non-tropical watches and warnings. Difficult to switch during event.
 - This practice has now changed post-Sandy





Unique Warning Challenges for Transitioning Tropical Cyclones



- Cyclone type and the associated transitions are 'shades of grey' or continuum issues.
- Operational handling of cyclone types is a 'black and white' or 'yes or no' response – tropical cyclone (TC) warnings or non-tropical gale/storm warnings.
- This situation can lead to issues and inconsistencies in the warning process, response, and climatology.
- **But, if *you* get hit by 75 mph winds, 10 ft above normal tides, and/or 12 in of rain, does the nature of the system really matter?**



“Post-Tropical” Terminology Adopted by CHC in 1998

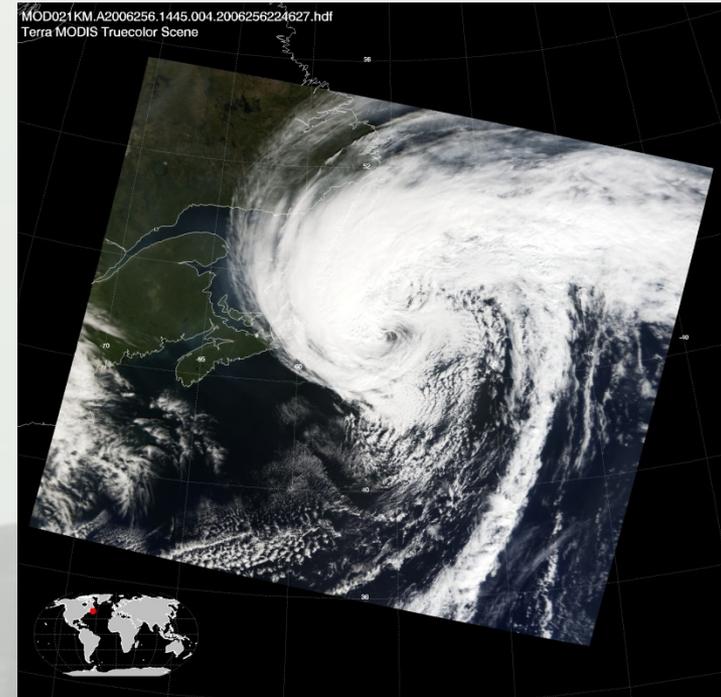
- **In the late 1990s, public surveyed to answer the question:
“What does it mean when a hurricane becomes extratropical?”**
- **With this convention, a potentially dangerous storm could be called post-tropical and its *name could still be used.***
- **Through continued use and public awareness efforts, this new naming practice has been accepted and has greatly helped communications with the public.**
- **CHC began the use of “Post-Tropical” classification during Hurricane Bonnie in 1998**



“Post-Tropical” Terminology Adopted by NHC in 2009



- Already used by the Canadian Hurricane Center to describe cyclones that no longer met the definition of a tropical cyclone, yet still posed a significant threat to life and property
- NHC used post-tropical terminology in the final advisory for systems that were no longer tropical
- NHC did not issue post-tropical advisories, handled in high seas forecasts (Marine Prediction Center) over water and potentially the Weather Prediction Center when over land and a rainfall threat.





NHC's Definition of a Post-Tropical Cyclone



A FORMER TROPICAL CYCLONE. THIS GENERIC TERM DESCRIBES A CYCLONE THAT **NO LONGER POSSESSES SUFFICIENT TROPICAL CHARACTERISTICS** TO BE CONSIDERED A TROPICAL CYCLONE. POST-TROPICAL CYCLONES CAN CONTINUE CARRYING HEAVY RAINS AND HIGH WINDS. FORMER TROPICAL CYCLONES THAT HAVE BECOME FULLY EXTRATROPICAL...AS WELL AS REMNANT LOWS...ARE TWO SPECIFIC CLASSES OF POST-TROPICAL CYCLONES

Post-Tropical

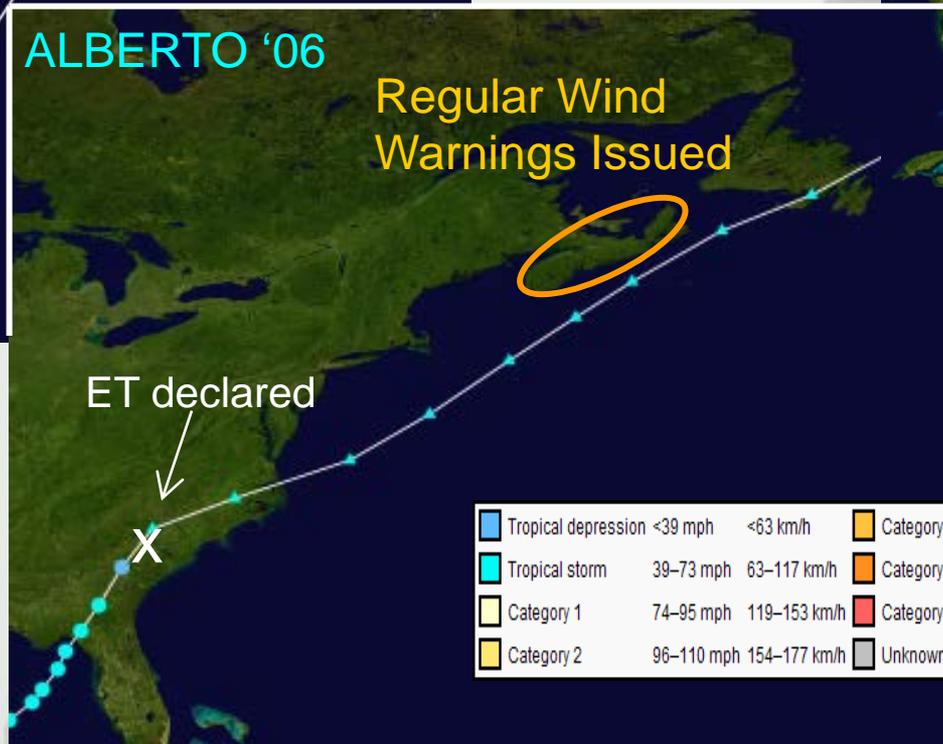
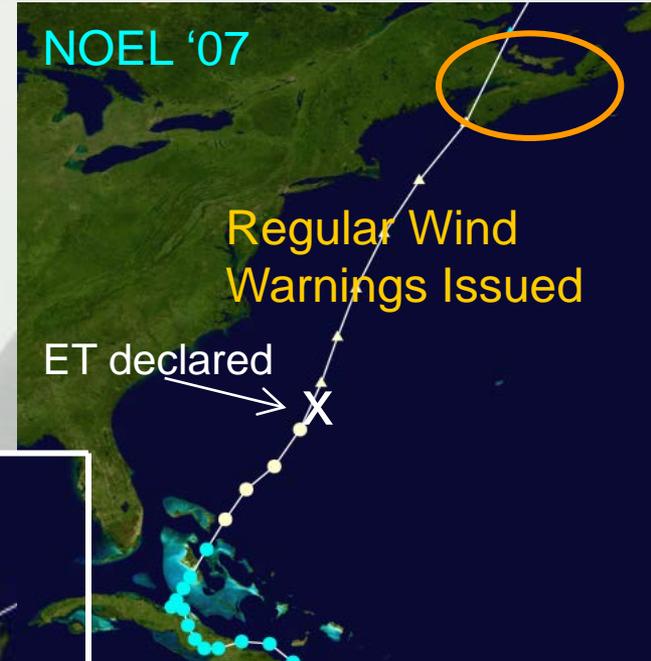
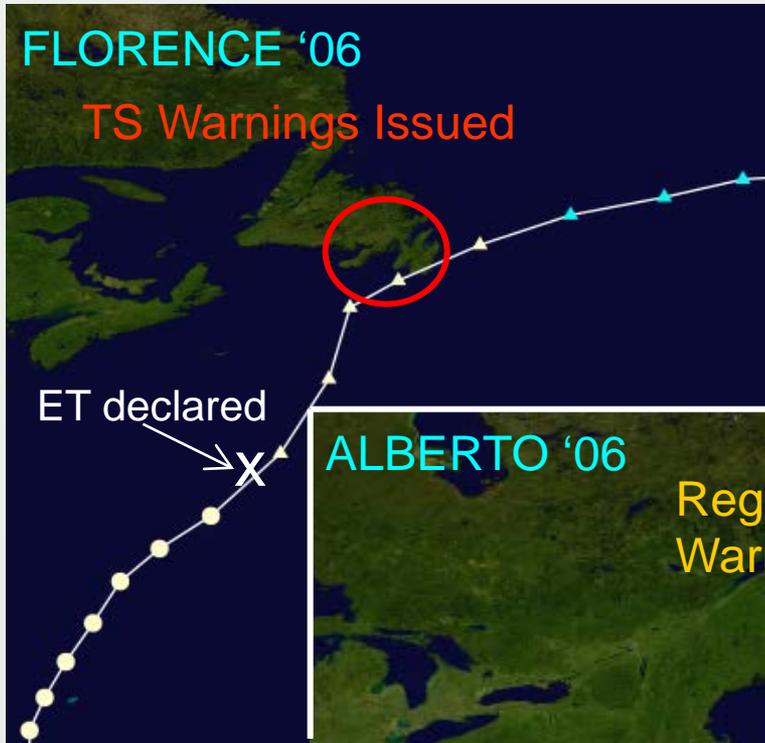
Extratropical Low

Any cyclone (including post-tropical) whose primary energy source is temperature contrasts between warm and cold air masses

Remnant Low

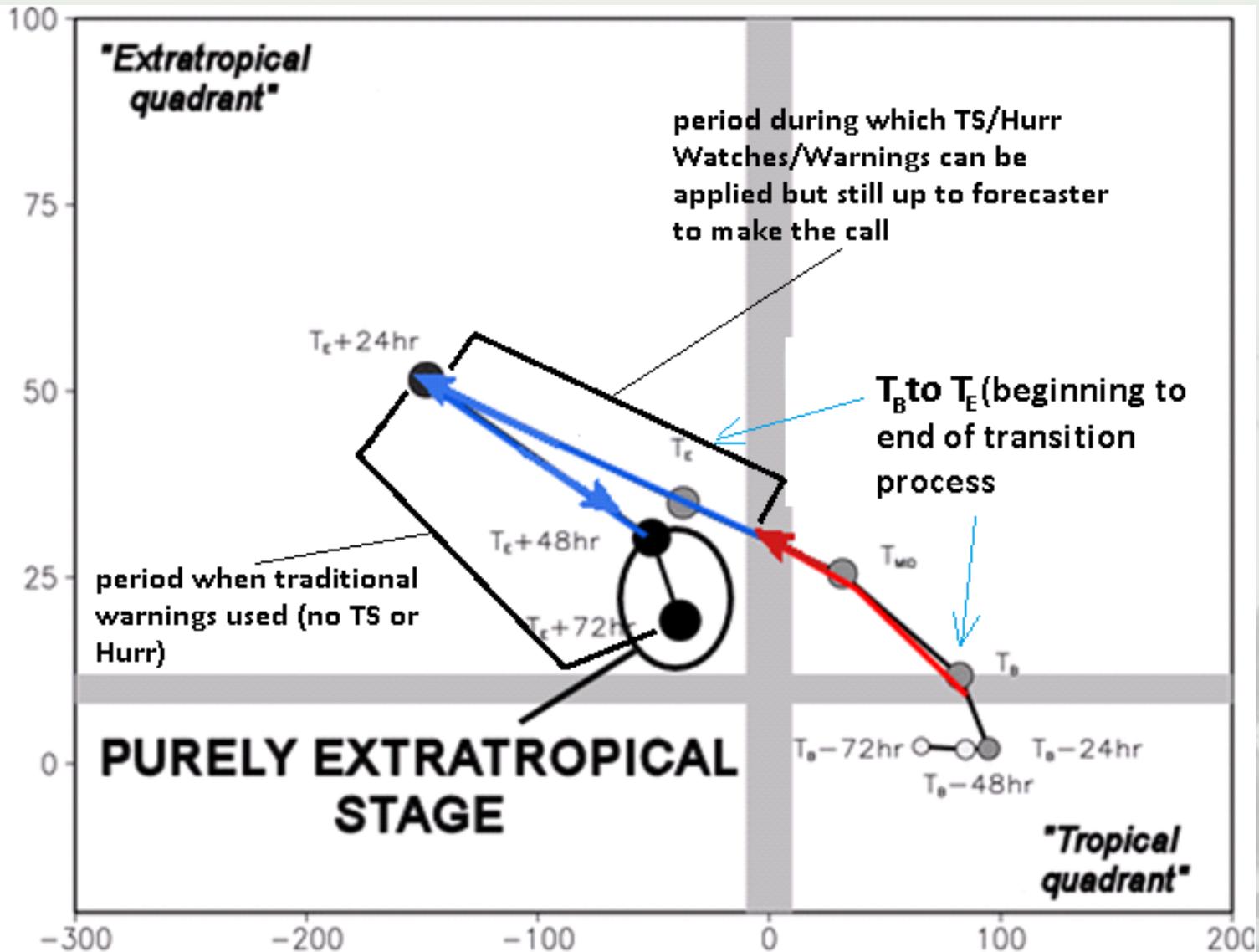
Post-tropical cyclone that no longer has the convective organization required of a tropical cyclone, maximum sustained winds less than 34 kt

CHC Case examples – tropical or non-tropical warnings



Tropical depression	<39 mph	<63 km/h	Category 3	111–129 mph	178–208 km/h	Tropical cyclone
Tropical storm	39–73 mph	63–117 km/h	Category 4	130–156 mph	209–251 km/h	Subtropical cyclone
Category 1	74–95 mph	119–153 km/h	Category 5	>156 mph	>251 km/h	Extratropical cyclone / Remnant low / Tropical disturbance
Category 2	96–110 mph	154–177 km/h	Unknown			

Tropical-type watches/warnings in the context of the Cyclone Phase Space





Warning Challenge- Sandy Example



Plenty of other similar cases in Canada prior to Sandy

- The dynamical models forecast Sandy to become extratropical before landfall, although the timing varied.
- **Once warnings are issued, it is difficult to switch between TC and non-TC warnings.**
- There were several combinations of possible warnings and storm evolution, all of which were problematic.
- TC warnings were eventually issued for coastal North Carolina, with non-TC warnings for the rest of the affected area.
- **During Sandy, the extratropical transition process did not reduce the threat at all!**





Meeting the Warning Challenges for 2013 and Beyond



- The NWS has broadened the tropical storm and hurricane watch and warning definitions to allow them to be used for post-tropical cyclones that pose a significant risk to life and property.
- NHC will have the option to continue advisory products on post-tropical cyclones that pose a risk to life/property and when the transfer of responsibility to another office would result in an unacceptable discontinuity in service.
- For several years, the NWS has been developing a **storm surge warning** that could be used independently of the expected winds and of the type of weather system producing it. This could be operational by 2015.



Tropical Storm Isaac Sunday August 26, 2012 5 AM EDT Advisory 21 NWS National Hurricane Center	Current Information: Center Location 23.1 N 79.0 W Max Sustained Wind 65 mph Movement NW at 18 mph	Forecast Positions: ● Tropical Cyclone ○ Post-Tropical Sustained Winds: D < 39 mph S 39-73 mph H 74-110 mph M > 110mph
Potential Track Area: Day 1-3 Day 4-5	Watches: Hurricane Trop.Storm	Warnings: Hurricane Trop.Storm



Hurricane Sandy Friday October 26, 2012 8 PM EDT Intermediate Advisory 18A NWS National Hurricane Center	Current Information: Center Location 27.5 N 77.2 W Max Sustained Wind 75 mph Movement N at 7 mph	Forecast Positions: ● Tropical Cyclone ○ Post-Tropical Sustained Winds: D < 39 mph S 39-73 mph H 74-110 mph M > 110mph
Potential Track Area: Day 1-3 Day 4-5	Watches: Hurricane Trop.Storm	Warnings: Hurricane Trop.Storm



Environment Canada - Storm Surge Warnings



- EC has been issuing storm surge warnings for many years
- Irrespective of cyclone type
- Co-exist with hurricane (and other) warnings
- From EC website:

Storm Surge

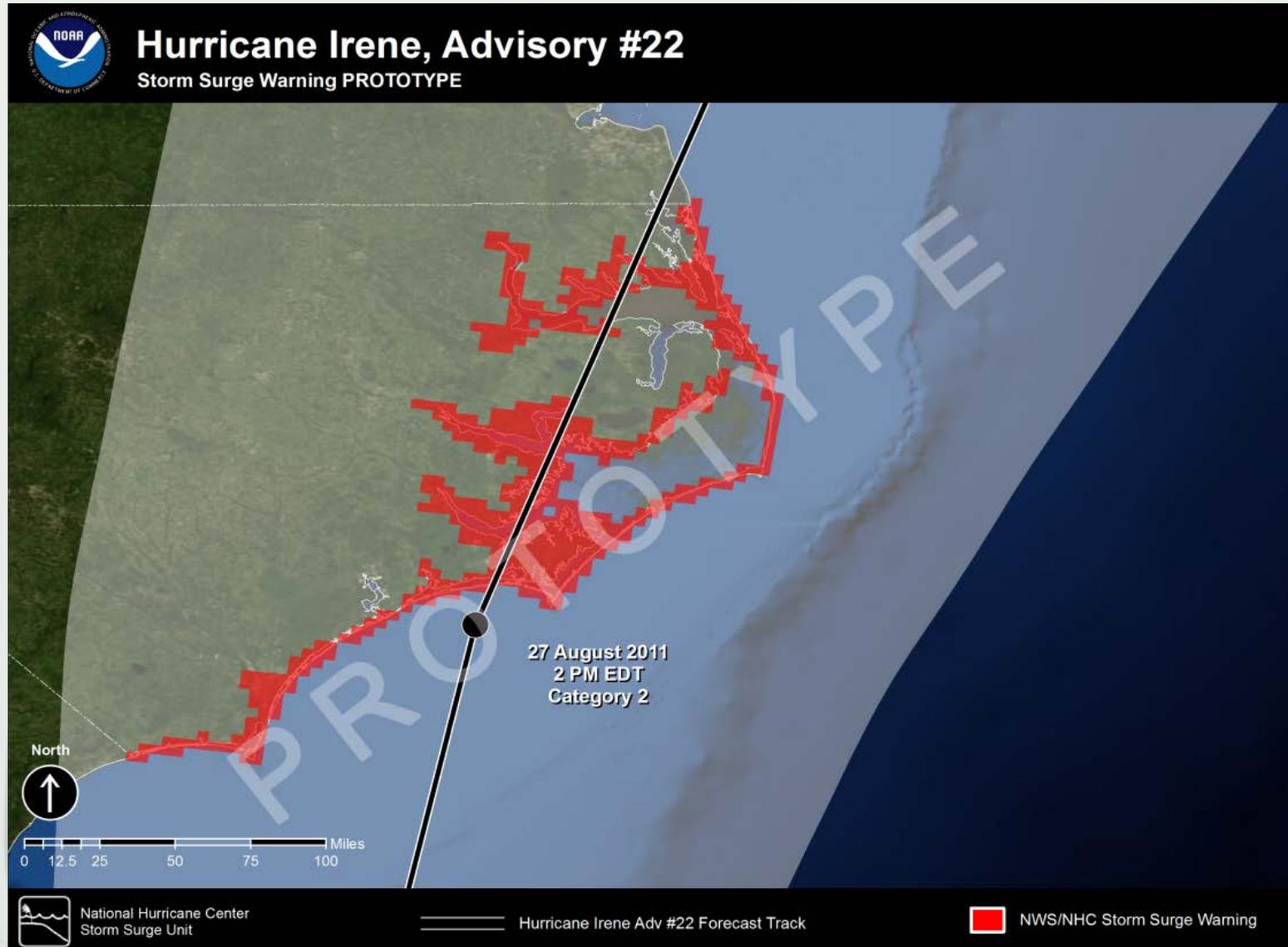
Table 20. Alerting parameters Environment Canada uses for issuing a Storm Surge Warning

Alert Type	Location	Threshold Criteria
Warning	Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador, Gulf of Saint Lawrence coastal areas and the Magdalen Islands (ONLY)	Issued for abnormally high water levels and high waves (storm surge or storm tide) caused by storms, which have the potential to cause coastal flooding. This usually occurs when astronomical tides are at their maximum.

- Descriptive text of the warning bulletin also refers to “pounding surf, erosion, damage to infrastructure...)
- No surge graphic products issued

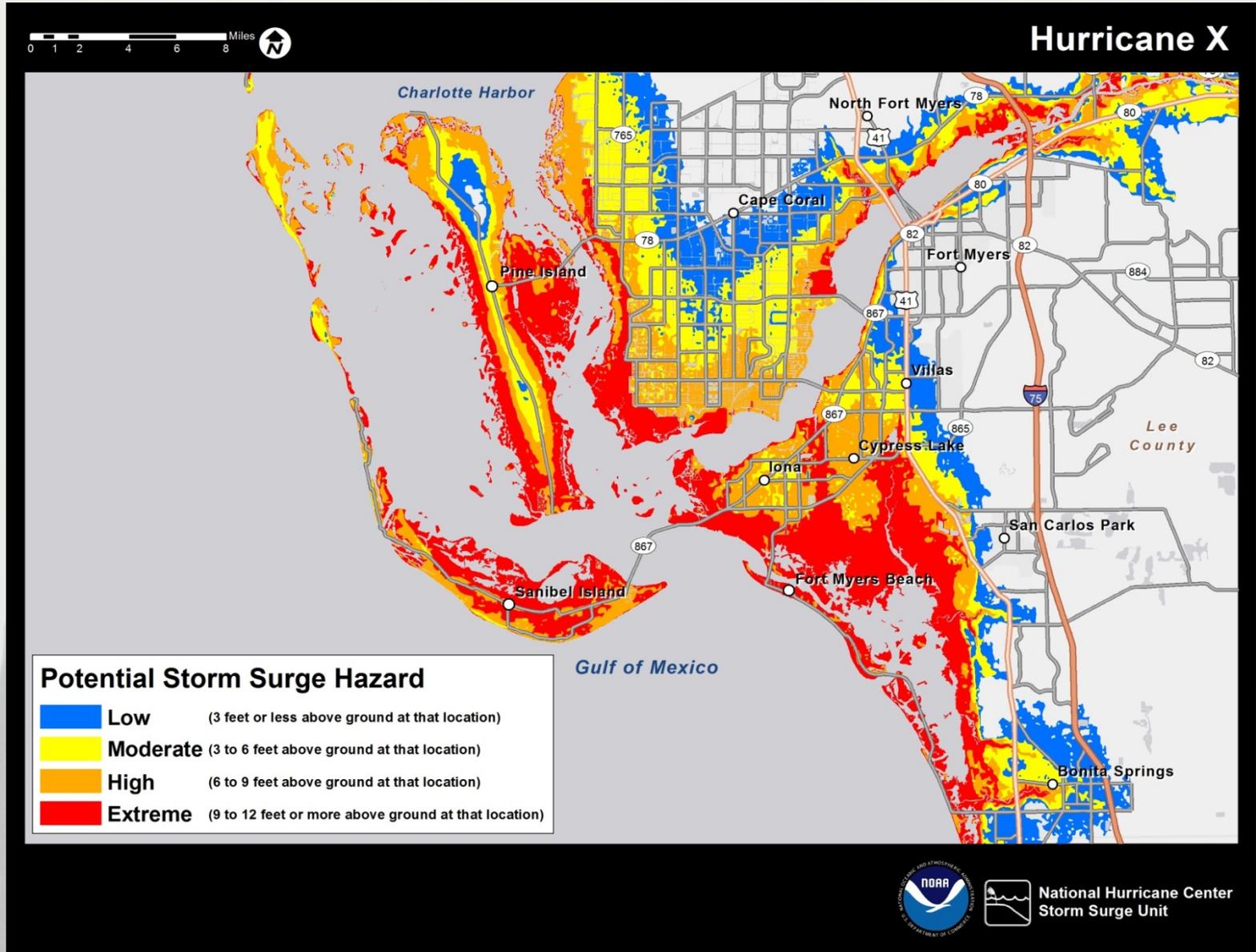


NHC/NWS Planning to Debut Storm Surge Warning in 2015





Potential Storm Surge Inundation Graphic for the U.S. in 2014



The background of the image shows several palm trees in silhouette against a very bright, almost white, hazy sky. The trees are leaning slightly to the right, suggesting a breeze. The overall tone is soft and ethereal.

**Comments /
Questions?**