Tropical Cyclone Rainfall

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NWS WFO Jacksonville, FL
Outline

• Tropical Cyclone (TC) rainfall climatology
• Factors influencing TC rainfall
• TC rainfall forecasting tools
• TC rainfall forecasting products
Tropical Cyclone Rainfall Climatology
## History of Major Florida TC Rainfall

<table>
<thead>
<tr>
<th>Rank</th>
<th>Precipitation (mm)</th>
<th>Precipitation (in)</th>
<th>Storm</th>
<th>Location</th>
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<td>649.2</td>
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<td>Homestead/Ira Ebersole</td>
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<td>Arcadia Tower</td>
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<td>24.98</td>
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<td>July 1916 Hurricane</td>
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<td>10</td>
<td>602.7</td>
<td>23.73</td>
<td>Dora 1964</td>
<td>Mayo</td>
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</table>
Tropical Storm Debby

- This tremendous amount of rainfall over a relatively short period of time resulted in flash flood type flooding on the Sopchoppy River.

- Debby's rainfall resulted in a maximum discharge of approximately 3,300 ft³/s, nearly 10 times the average discharge of 391 ft³/s.
TC Rainfall Over Florida

FL Fixes 2004–2013
Accumulated Rainfall (in)
A Tale of Two Storms

Rainfall Accumulation (in) from Debby and Fay
A Tale of Two Storms

50-70% of all TC Rainfall in 10 years came from Debby and Fay.
Factors Influencing Tropical Cyclone Rainfall
What Factors Influence Rainfall from Tropical Cyclones?

• Movement – slow forward motion can produce more rain

• Storm size – the larger the storm, the greater the area typically receiving rain

• Storm track – factor in the location of the rain

• Diurnal cycle – heaviest rainfall generally near the storm center overnight, outer band rainfall during the day

• Topography – enhances rainfall in upslope areas, but decreases rainfall past the spine of the mountains

• Moisture – Entrainment of dry air can redistribute and/or reduce the amount of precipitation; increased moisture can increase rainfall

• Interaction with other meteorological features (troughs, fronts, jets) and extratropical transition can greatly modify rainfall distribution
Factors Influencing TC Rainfall

Storm Motion
• Slow vs. fast moving TCs
• TCs with a turning or looping track vs. straight mover

Hurricane Mitch fatalities:
Honduras: 5,677
Nicaragua: 2,863
Guatemala: 258
El Salvador: 239

Vulcan Casita, Nicaragua - debris flows

Tegucigalpa, Honduras river flooding

Rainfall in Inches
1 Inch = 25.4 mm

David Roth HPC
Factors Influencing TC Rainfall

Time of Day
Alberto, July 4-5, 1994

04/18z  00z  05/06z  12z  18z
Factors Influencing TC Rainfall

Time of Day
Alberto, July 4-5, 1994

04/18z 00z
05/06z 12z 18z
Rainfall Banding

00Z23AUG2008 6h Rainfall (in)
Tropical Storm Debby

300 km (186 miles) between center and maximum rainfall
Factors Influencing TC Rainfall

Terrain Impacts
Heaviest rainfall favors mountains perpendicular to the wind

Hurricane Georges in Puerto Rico
$1.75 billion in damage
28,005 homes destroyed
Where is Flooding from Tropical Cyclones Likely to Occur?

- Areas Where the Ground is Already Saturated (Low Flash Flood Values)
- Valleys/Watersheds
- Areas of Terrain Enhancement
- Areas with Poor Drainage or Prone to Runoff
- Areas with Directed Drainage that can be Overwhelmed

Floyd 1999 - Tar River, NC
NC: 35 deaths

Gaston 2002 - Shockoe Bottom
City of Richmond: $7.9 mil
Warning Signs for Heavy Rainfall Associated with TCs

Saturated Soil

T.S. Dennis
Aug 28-Sep 8
Ocracoke 19.91”

Hurricane Floyd
September 14-17, 1999

Maximum: 24.06"
Southport 5N, NC
Warning Signs for Heavy Rainfall Associated with TCs

- Slow moving TCs
- TCs with a turning or looping track

T.S. Allison $4.8 billion in damage in Houston alone

T.S. Allison
June 4-17, 2001
2,429 sites

Maximum: 40.68"
Moore Road Detention Pond/NW Jefferson County, TX
Tropical Storm Allison 2001

Houston, TX

$5.5 Billion, 41 Fatalities
Tropical Storm Fay (2012)
Slow Forward Motion
Tropical Storm Fay (2012)
Slow Forward Motion
Tropical Storm Fay

TS Fay Rainfall Accumulation (inches)
Warning Signs for Heavy Rainfall Associated with TCs

Peeks Creek Debris Flow
2.25 miles down-slope
5 deaths

Terrain Impacts
Tropical Storm Fay (2008)
Orographic Interaction
Tropical Storm Fay (2008)  
Orographic Interaction

Cavalier Apartments during Fay flood

A tow truck driver wades through waist-deep water to assist motorists as Stewart Creek overtops Morehead Street. (Photograph from *The Charlotte Observer/Kent D. Johnson*)
Tropical Storm Debby (2012)
Interaction With A Pre-existing Boundary
Tropical Storm Debby (2012)
Interaction With A Pre-existing Boundary
Tropical Storm Debby (2012) Interaction With A Pre-existing Boundary

- Most of the rain and weather TS Debby were well to the north and east of the center over Florida.

- Northern and Central FL were effectively inundated with rain squalls originating over the Gulf and wrapping around the eastern side of the storm for 3 days with copious amounts of rain.

- The heaviest rains cover a wide patch of central Florida from around Titusville on the east coast to around Homosassa Springs on the west coast within which amounts exceeded 10 inches to over 15 inches in the center.

- Another band of heavy rain is oriented east-west across northern Florida from Jacksonville to near Tallahassee with similar amounts or rain. The highest totals in the band occur around Lake City and exceeded 15 inches. This east-west band can be attributed to moist flow from the GOMEX and a frontal boundary draped across southern Georgia in an east-west orientation.
Tropical Storm Debby

TS Debby Rainfall Accumulation (inches)
TC Rainfall Forecasting Tools
Kraft Rule
We’ve come a long way!

Developed in the 1950s by a Hurricane Forecaster R. H. Kraft

T.C. Rainfall = 100/Forward Motion in Knots
Storm Moving at 25 knots = 4 inches
Storm Moving at 10 knots = 10 inches
Storm Moving at 05 knots = 20 inches
Forecaster Improvements over the Models

Forecaster adjusts models for NHC forecast, known model biases, and impacts of surrounding meteorological features.
Scenario

• Tropical Cyclone (TC) “X” is a week or more away from approaching your area
• What information is available?
• How do I assess the risk of fresh water flooding in my area?
1 Week Before TC Rain Begins
Assess Likelihood of Ground Saturation

- **Drought monitor:**
  [http://drought.unl.edu/DM/MONITOR.html](http://drought.unl.edu/DM/MONITOR.html)

- **Hazards Assessment:**
4-5 Days Before TC Rains Begin
5 Day Quantitative Precipitation Forecast

Weather Prediction Center (WPC) 5 Day QPF
http://www.hpc.ncep.noaa.gov/qpf/day1-7.shtml
Flash Flood Guidance

Amount of rain over a specified time period that will produce flash flooding by county (less in urban areas)

http://www.srh.noaa.gov/rfcshare/ffg.php
Excessive Rainfall Graphics

Risk of Exceeding Flash Flood Guidance:
• Slight (SLGT) 5-10%
• Moderate (MDT) 10-15%
• High (HIGH) >15%

Done for Days 1, 2, & 3 (24 hr forecast periods)

Area where Maximum Rainfall may Exceed 5 Inches Highlighted for Day 1 Only

http://www.wpc.ncep.noaa.gov/qpf/excess_rain.shtml
During TC Event
Local Weather Forecast Office

- Near term QPF
- Local Watches/Warnings/Advisories
- Local Statements and Nowcasts
- Graphicast

http://weather.gov
Click on map for local office
During TC Event
Local Weather Forecast Office

Today & Wednesday

3-Day Rainfall Outlook: 7/1-7/4
1-2 inches likely south of St. Augustine along coast

Local Forecast Today & Wednesday
Low rain chances today; higher Wednesday

Elevated Risk
Increasing onshore flow & building swells will create dangerous rip currents along the local Atlantic coast.
### 5 Day Rain Totals (Inches)

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<th>County</th>
<th>TUE</th>
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<th>FRI</th>
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**During TC Event**

Local Weather Forecast Office

- Used in Social Media and GTM Partner Briefings
- Graphical partner emails
- EM specific tropical webpage

**EM-Brief**
During TC Event
Southeast River Forecast Center

Subtropical Storm Ana 2015

http://www.srh.noaa.gov/serfc/?n=qpfpage
http://digital.weather.gov/
During TC Event
Local Weather Forecast Office

- Flash Flood Warnings!

http://weather.gov
Click on map for local office
How Much Rain Fell?
Weather Prediction Center

- **WPC Tropical Cyclone Public Advisories**
  (available at same issuance times as NHC Public Advisories)

- **Storm specific rainfall accumulation graphics**
  (available several weeks later)

http://www.wpc.ncep.noaa.gov/tropical/tropstorms.shtml
How Much Rain Fell?
River Forecast Center

http://water.weather.gov/precip/
In Conclusion

• Remember the factors that influence TC rainfall (size of storm, time of day, speed etc.)

• NWS assesses environmental conditions: the amount of shear, track, moisture transport, existing boundaries and soil moisture, storm symmetry. How will it influence rainfall and rainfall distribution?

• Use all of the tools available (products and services from NHC, Local WFOs, RFC)

• Remember, heavy rain can also occur well away from the TC itself.
Thank You

Questions?