

Tropical Cyclone Quantitative Precipitation Forecasting



Russell Pfost
Meteorologist-in-Charge
National Weather Service
Weather Forecast Office
Miami, Florida

Turn Around, Don't Drown!

Even in Florida, people drive into ditches and canals!



Turn Around, Don't Drown!

Sometimes with DISASTROUS results!





Tropical Cyclone Rainfall

Rappaport, Fuchs, and Lorentson (1999)

- Floods due to torrential rains (1970-1999) accounted for:
 - ▶ 292 deaths out of 510 (59%)
 - ▶ About 78% of children's deaths
 - ▶ Large loss of life due to flooding in particular tropical cyclones
 - Agnes, 1972 (114)
 - Alberto, 1994 (33)
 - Amelia, 1978 (33)
- No relationship apparent between intensity of tropical cyclone at landfall and the number of rainfall induced flood deaths

Tropical Cyclone Rainfall

Introduction

- Two features distinguish tropical rains from mid latitude rains
 - ▶ High temperature
 - ▶ High humidity (high liquid water content)
- Tropical Cyclones combine higher liquid water content with extreme convection
- Tropical Cyclones have the potential for extreme amounts of rain

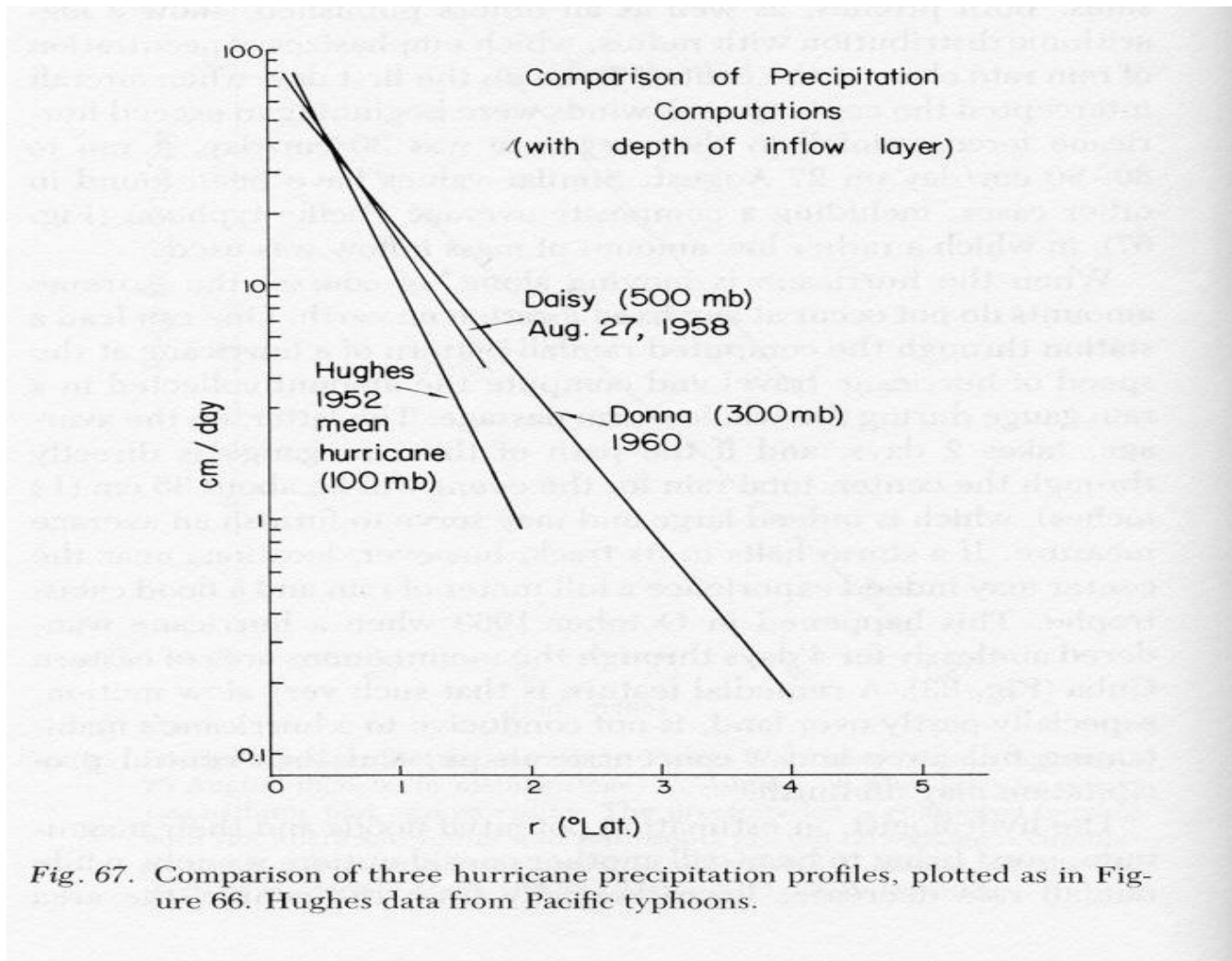
Tropical Cyclone Precipitation

Factors to Consider

- Most rain occurs in the high wind area - estimates are that not more than 50% is caught
- Movement, progression, size
- Widely differencing values reported worldwide (trace to more than 100 inches (typhoon))
- Occurrence often in late stages away from tropics
- Logarithmic distribution with radius

Tropical Cyclone Precipitation

Precipitation Intensity Profiles (from Simpson and Riehl)



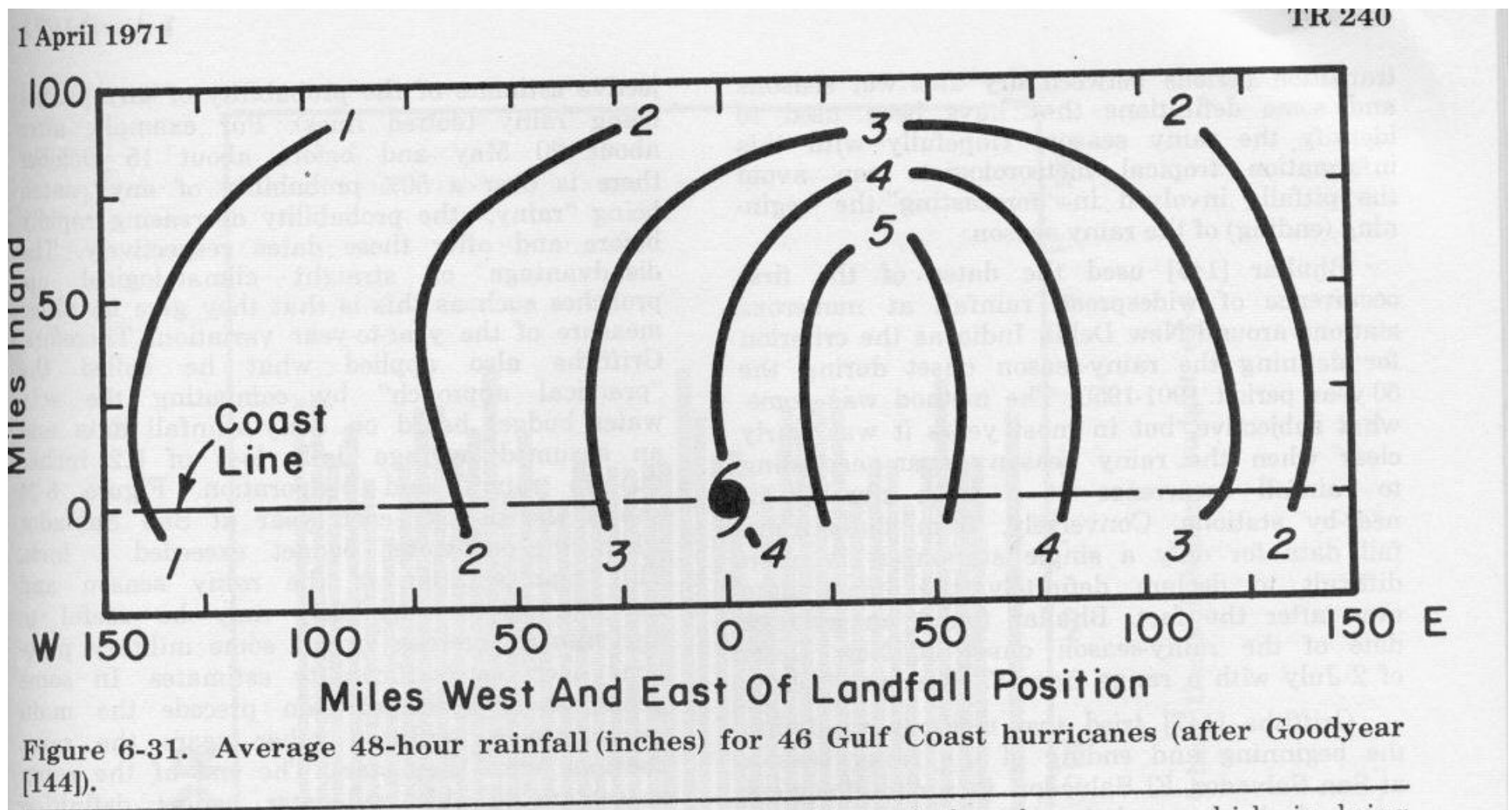
Tropical Cyclone Rainfall

Characteristics

- Extremely heavy rainfall
 - ▶ Eye wall
 - ▶ Spiral bands
- Dry side and wet side (Goodyear 1968)
- Average maximum for Gulf coast landfalling tropical cyclones and hurricanes... almost 6 inches
- Slightly inland from the coast
- 25 to 50 miles to the right of the storm track
- Varies tremendously with storm speed

Average 48 hr Rainfall

46 Gulf coast tropical storms and hurricanes



Tropical Cyclone Rainfall Patterns

Torrential Rains

- Typically 5 to 12 inches of rain in a hurricane
- Varies greatly depending on storm speed and size
- Extreme rainfall rates
 - ▶ 1.3 inches of rain in 10 minutes at Miami 1947
 - ▶ 6 inches of rain in one hour near Ft. Lauderdale 1947
 - ▶ 6 inches of rain in one hour at Hialeah 1947
 - ▶ 16.4 inches of rain in a few hours near Blountstown in 1926
 - ▶ 38.7 inches of rain in 24 hours at Yankeetown in 1950
 - ▶ 43 inches of rain in 24 hours at Alvin, TX, in 1979

Tropical Storm Alberto

July 1994

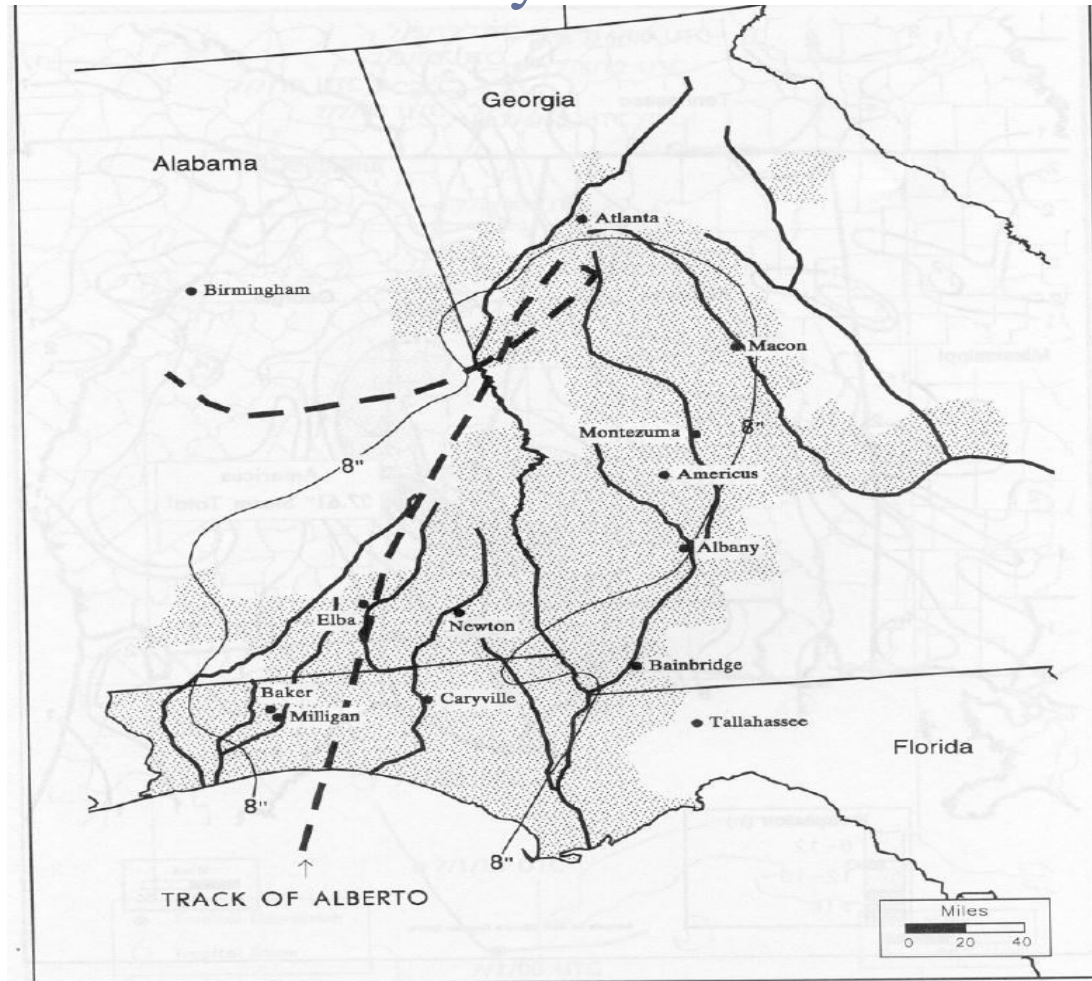
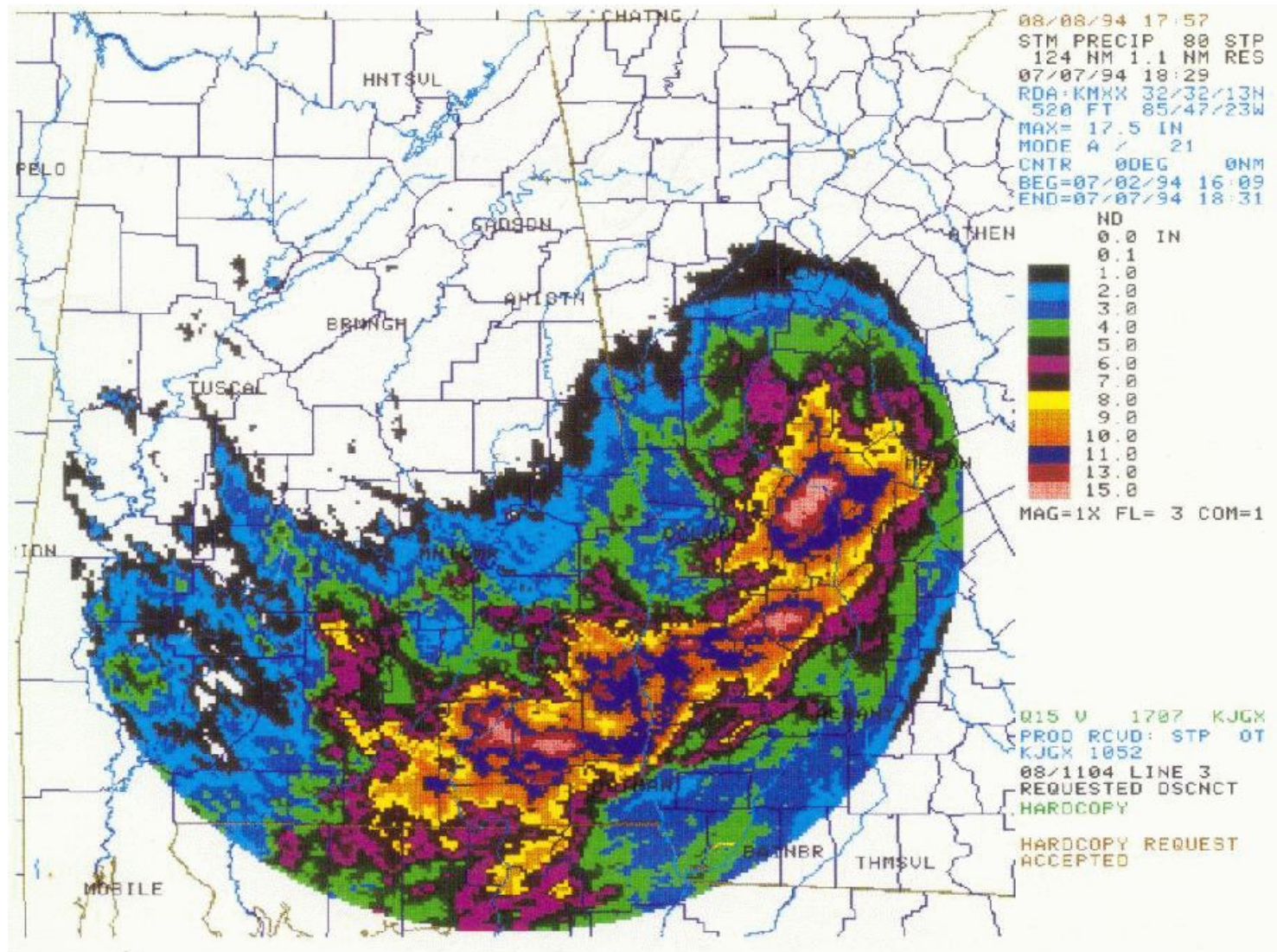


Figure 1-5. Composite showing Alberto's inland track (dashed line), the 8-inch isohyet, the 78 counties declared Federal disaster areas (shaded), and the five major river systems.

Tropical Storm Alberto

WSR-88D Rainfall Estimates



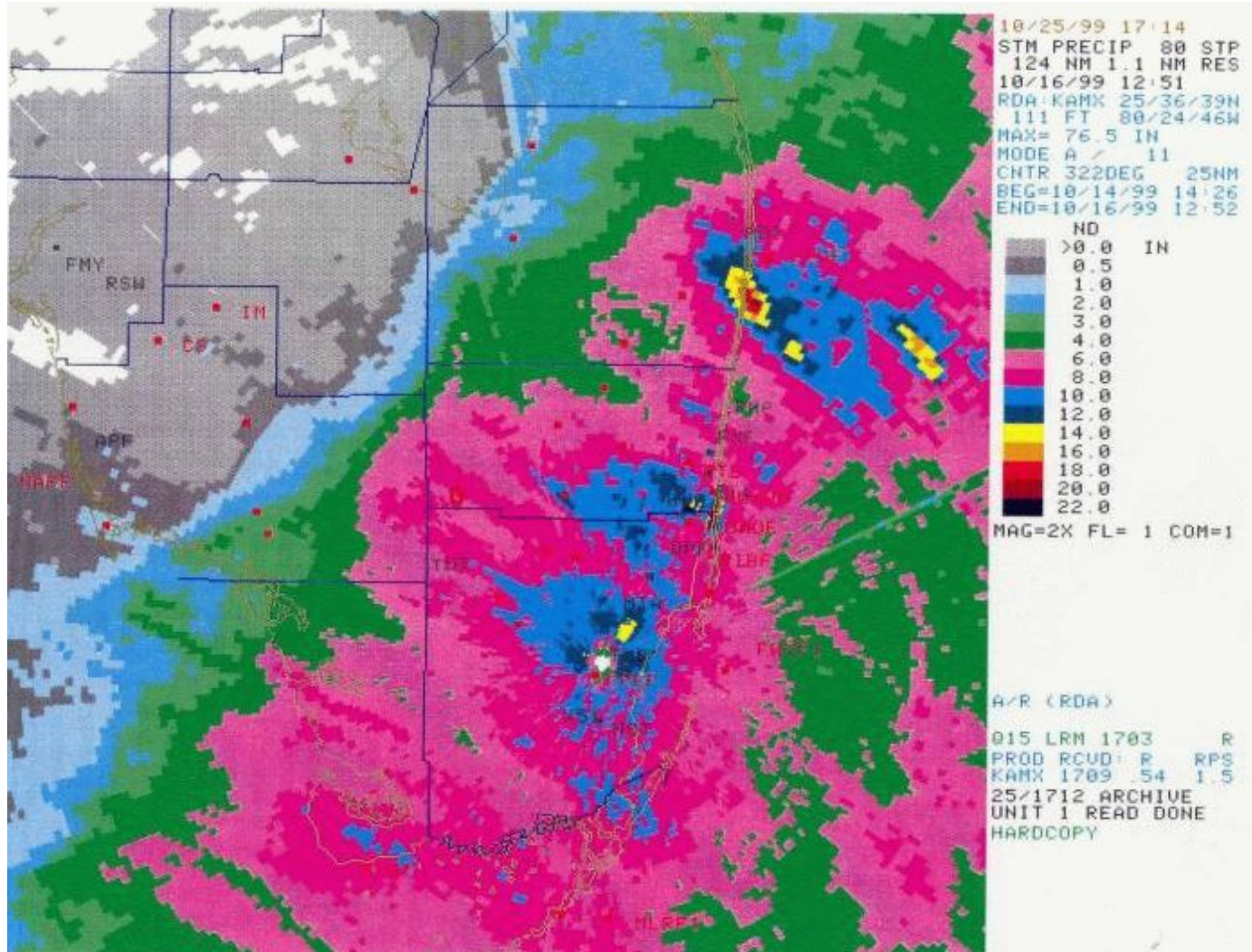
WSR-88D Doppler Radar

Factors to Remember

- **Reflectivity-Rainfall Relationships Z-R**
 - ▶ Used to be only TWO authorized Z-Rs
 - Standard Z-R $Z=300R^{1.4}$
 - Pretty good for thunderstorms and “normal” convection
 - Terrible for “low topped warm” convection
 - Tropical Z-R $Z=250R^{1.2}$
 - Works for purely tropical cases
 - In some storms overestimates
 - New research suggests the tropical Z-R is too heavy handed
 - ▶ When using WSR-88D rainfall estimates, especially for tropical cyclones, find out which Z-R is in use!
 - Standard Z-R will grossly underestimate tropical rains
 - Tropical Z-R will grossly overestimate normal convection especially north of 30 degrees N.

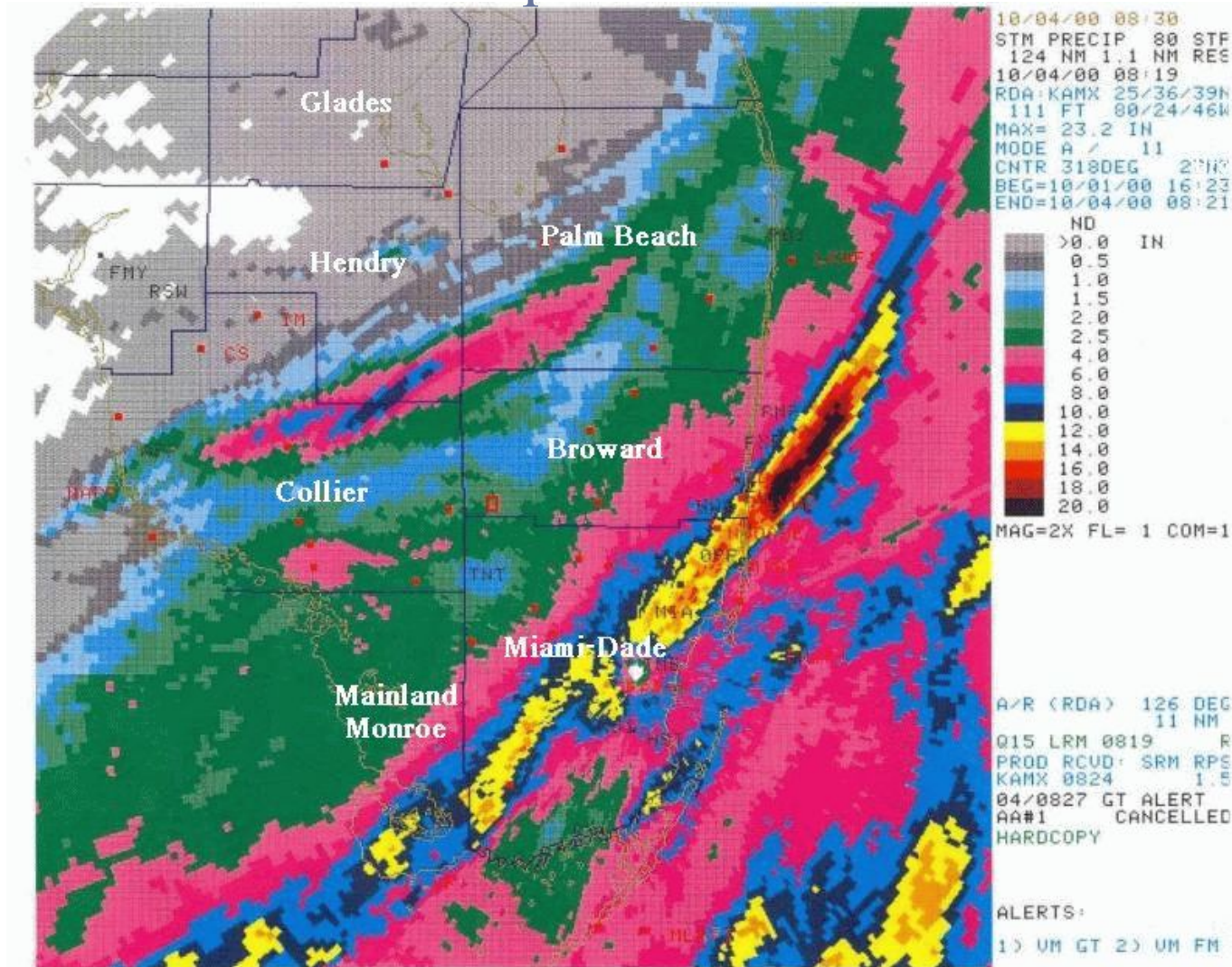
Hurricane Irene

WSR-88D Rainfall Estimates



Oct.3,2000 Disturbance

Another Flood Episode for South Florida

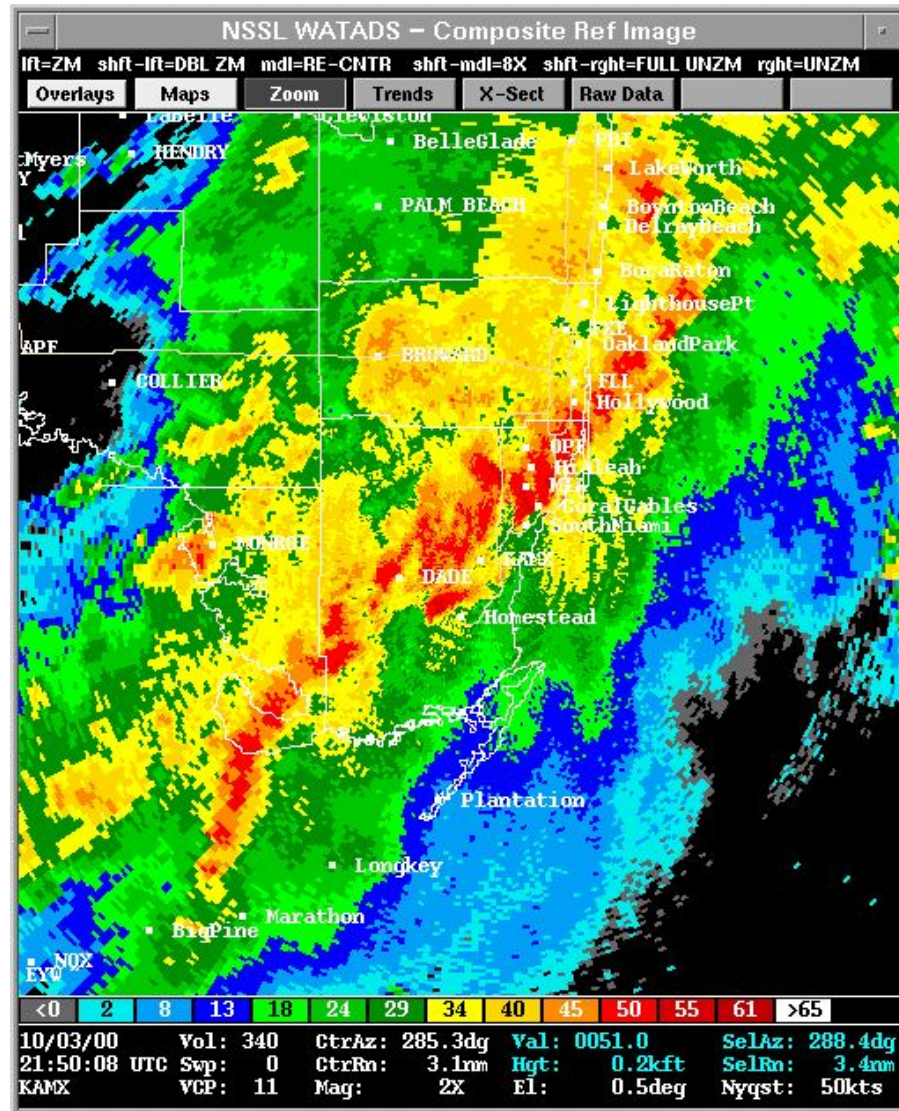


What was the difference?

Irene 1999 event and the Oct. 3, 2000, disturbance event

- Oct. 3 more localized to Miami-Dade County
- More rain (up to 17.5 inches, mostly 14-16 max)
- Shorter time period (most fell in less than 18 hours)
- Urban setting
- Train echo effect over a localized area
- Drainage poor in areas that used to be a swamp

TRAIN ECHO EFFECT



Tropical Cyclone Rainfall Patterns

Dry or low-rainfall hurricanes

- Usually fast moving
- 1941 Miami hurricane dropped less than .5 inch
- Andrew 1992 produced 7.5 inches at Tamiami Airport in Miami, but most amounts less than 4 inches

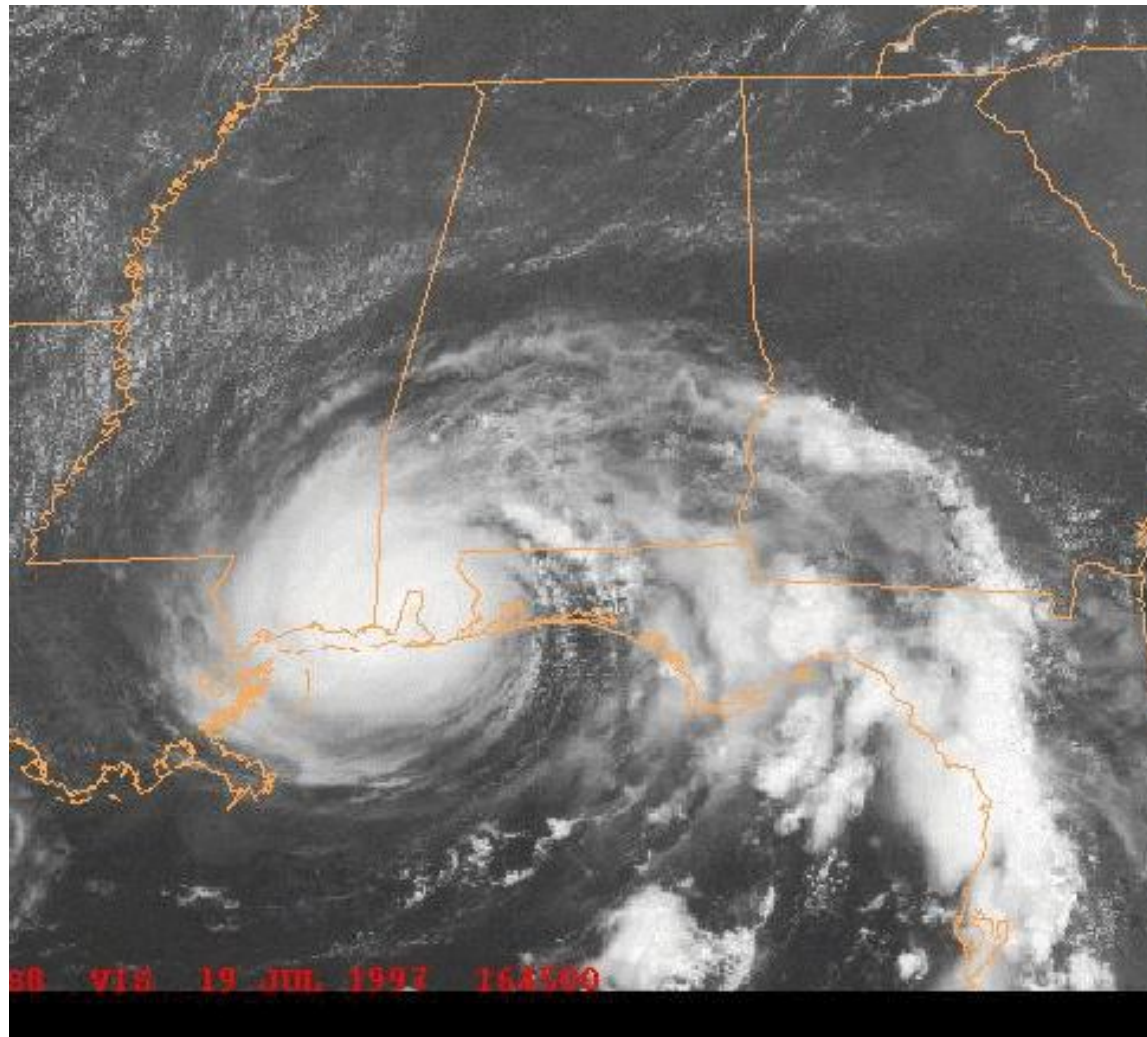
Tropical Cyclone Rainfall Pattern

Flooding

- Many of Florida's disastrous floods are the result of tropical cyclone rainfall
 - ▶ Hurricane Dora 1964 - 23.73 inches at Mayo... disastrous flooding N Florida including Live Oak
 - ▶ October 1924 hurricane - 23.22 inches at Marco Island...flooding lasted for days
 - ▶ September-October 1948 - widespread flooding around Lake Okeechobee (Clewiston, LaBelle) lasted for days
 - ▶ Tropical Storm Alberto 1994 - Apalachicola River
 - ▶ Tropical Storm Jerry 1995 - Collier County
 - ▶ Hurricane Irene 1999 - Southeast Florida

Hurricane Danny

Example of a stalled coastal storm



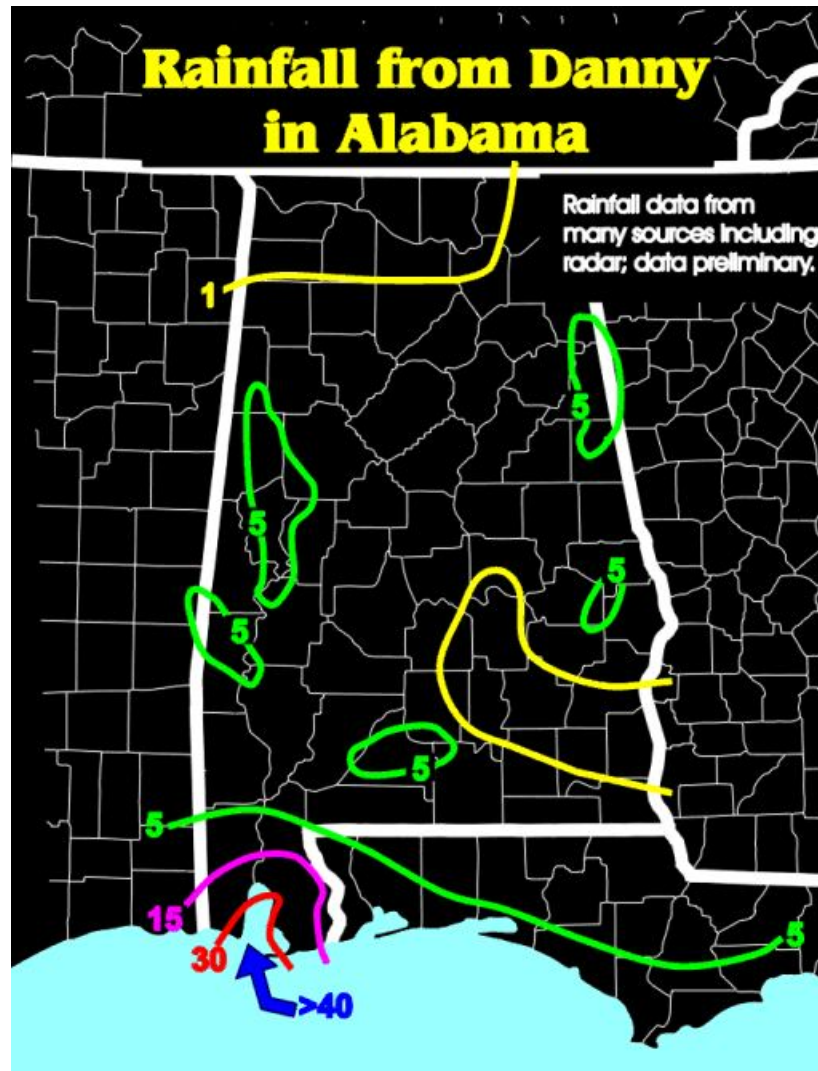
Hurricane Danny

Stalled coastal storm



Hurricane Danny

Rainfall Analysis



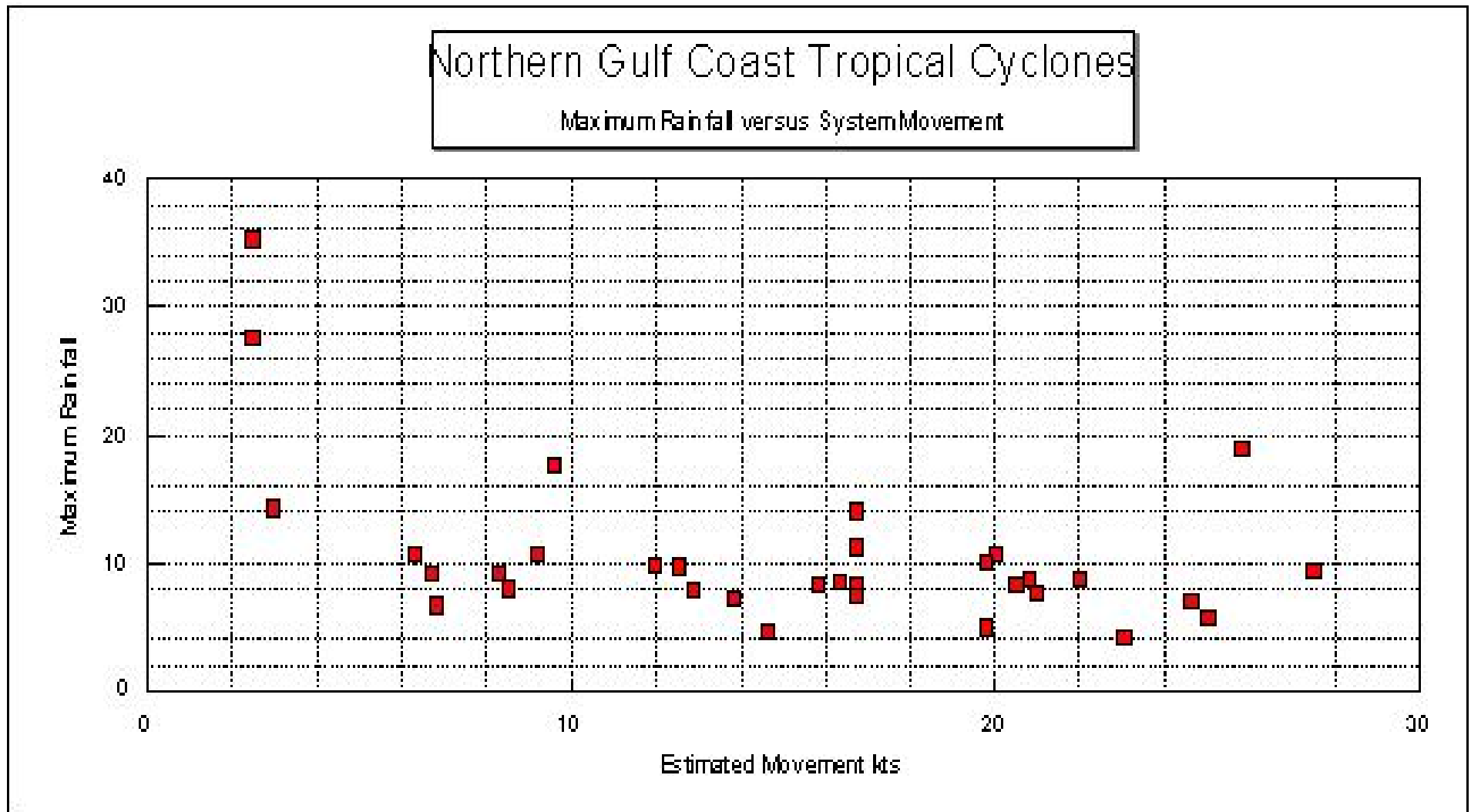
Kraft Rule of Thumb (old)

1960s

- Estimated Maximum Rainfall for hurricanes affecting the U.S. Gulf of Mexico coast
- Max Precipitation = $100 / \text{Speed (kts)}$
 - ▶ Example... Andrew max precip forecast $100/17.5 = 5.7$ inches
 - ▶ Actual max was 7.5 inches at Tamiami Airport
 - ▶ Good for a first guesstimate

Extreme Rainfall

Northern Gulf Coast LCH-AQQ

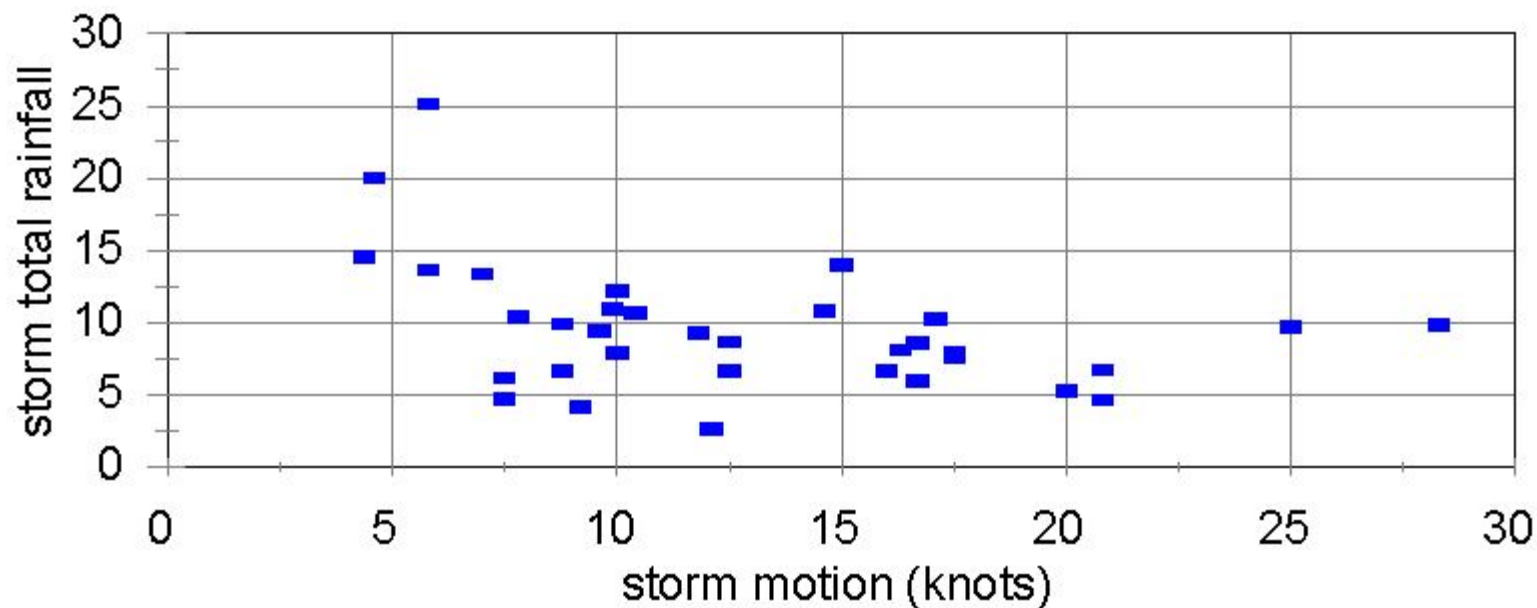


Extreme Rainfall

Florida Peninsula AQQ-JAX

Florida Tropical Cyclone Rainfall

1960-1998



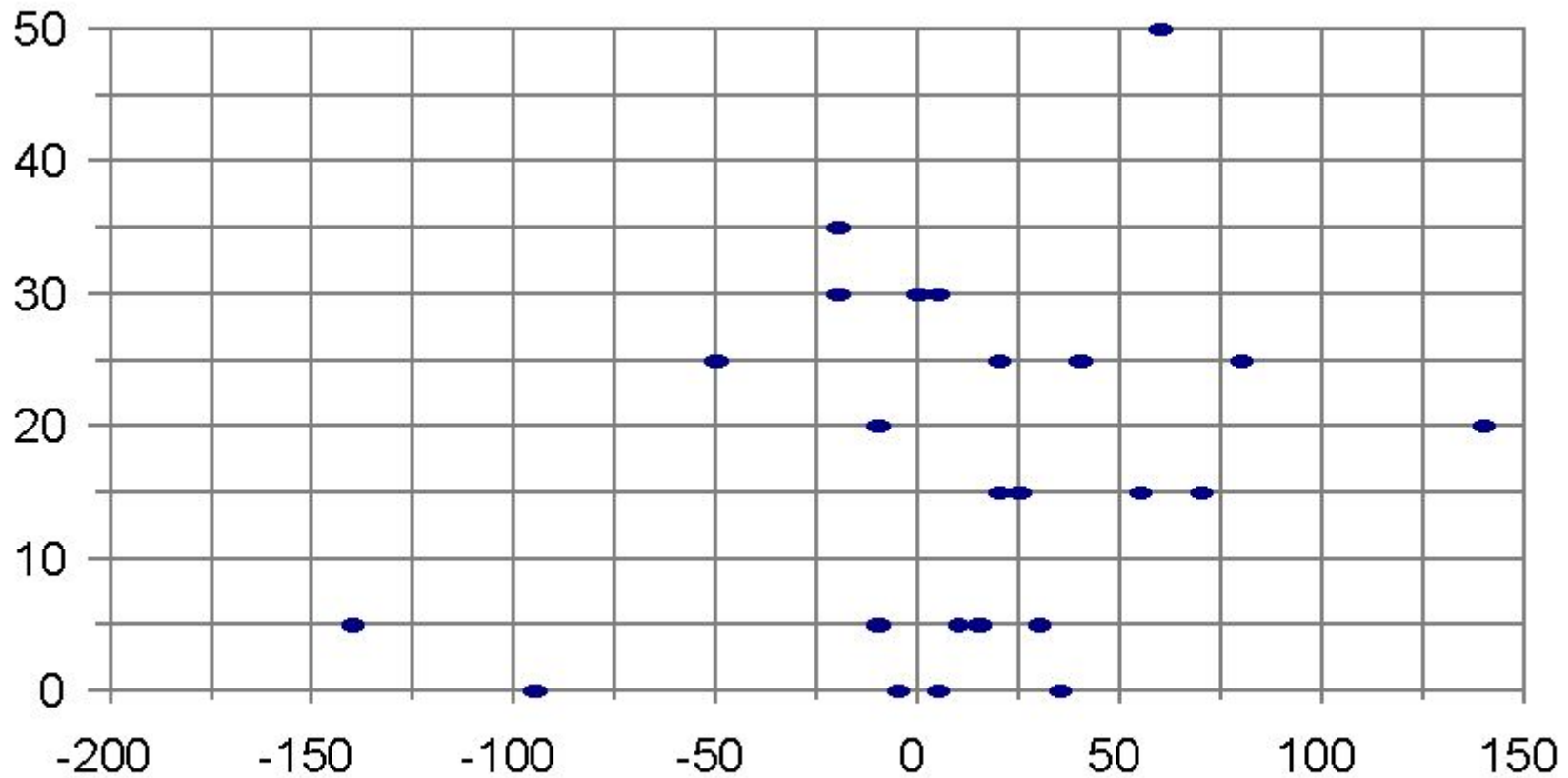
Extreme Rainfall

Regression Results

- Remove Outliers below 6 knots movement
- Gulf Coast landfall $R = -0.039(\text{movement}) + 9.75$
 - ▶ Standard deviation 3.3 inches
- Florida landfall $R = -0.063(\text{movement}) + 9.37$
 - ▶ Standard deviation 3.2 inches

Extreme Rainfall Distribution

Florida Landfalls



Position of Extreme Rainfall

What have we learned?

- Gulf Coast and Florida Peninsula Landfalls
 - ▶ 50 miles west (left) and up to 100 miles east (right) and up to 100 miles inland of landfall spot
 - ▶ Approximately 9-10 inches +/- 3 inches in RFQ (6 kt <movement<30 kt)
 - ▶ At least double forecast amounts movement less than 6 kt
- Greatest extreme rainfall threat usually removed from the track of the center of the tropical cyclone
- Tendency of public to focus on track of the center

NWS Guidance for Tropical Cyclone Rainfall

Primarily the Responsibility of the WFO

- NHC and HPC provide general QPF
- Local WFO provides specifics down to the county level
 - ▶ Coordination with local Water Districts and Corps of Engineers
 - ▶ Flood Watches
 - ▶ River Flood and Flash Flood Warnings
 - ▶ Short Term Forecast Updates and Flood Statements based on WSR-88D trends
 - ▶ GET THE MESSAGE TO THE PUBLIC

FLOOD WATCH

Uncommon Product for Florida

- Conditions are favorable for heavy rains and flooding during the watch period
 - ▶ Soil moisture high
 - ▶ Ground water level high
 - ▶ High runoff potential
 - ▶ Large amounts of rainfall likely
 - ▶ Poor drainage
 - ▶ Canals or rivers high and little capacity left to handle more runoff
- Make preparations now for future flood problems

Urban Flood Advisory

Intermediate Product

- Product Issued for nuisance type flooding rains
- Flooding of underpasses and low lying areas
- Flooding of normally poorly drained areas
- Issued as a Flood Statement (FLS)

FLASH FLOOD WARNING

Uncommon Emergency Product

- Flooding is imminent or has been reported
- Means that water will be or is now entering homes and businesses
- Requires immediate action to protect life and property
- Dangerous driving conditions
- Most deaths due to floods are because people insist on attempting to drive through flood waters
- Doesn't take much water depth to float vehicles

South Florida after Hurricane Irene



Sun-Sentinel online

National Weather Service

Weather Forecast Office
11691 SW 17th Street
Miami, Florida 33165
305-229-4502

<http://miamiweather.info>

En español <http://el tiempo en miami.info>

