Sept. 18, 2009
Hurricane Floyd Symposium

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BACK TO THE FUTURE:

Satellite Precipitation as a Tool to Reanalyze Hurricane Floyd and Forecast Probabilities of Extreme Rainfall

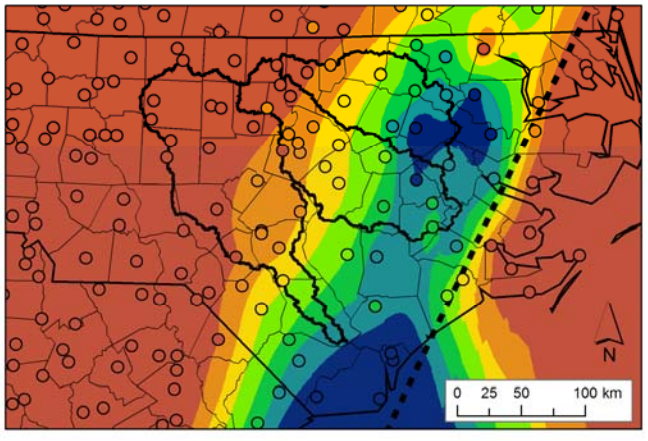
Motivation

- What was the freshwater input to the Tar, Neuse, and Cape Fear River basins?
  - Curtis, Crawford, Lecce in *Nat Hazards* (2007) 43:187-198
- How much rain did Dennis and Floyd produce during their tracks?
- Did more rain fall in Eastern North Carolina than anywhere else on the planet during Floyd?

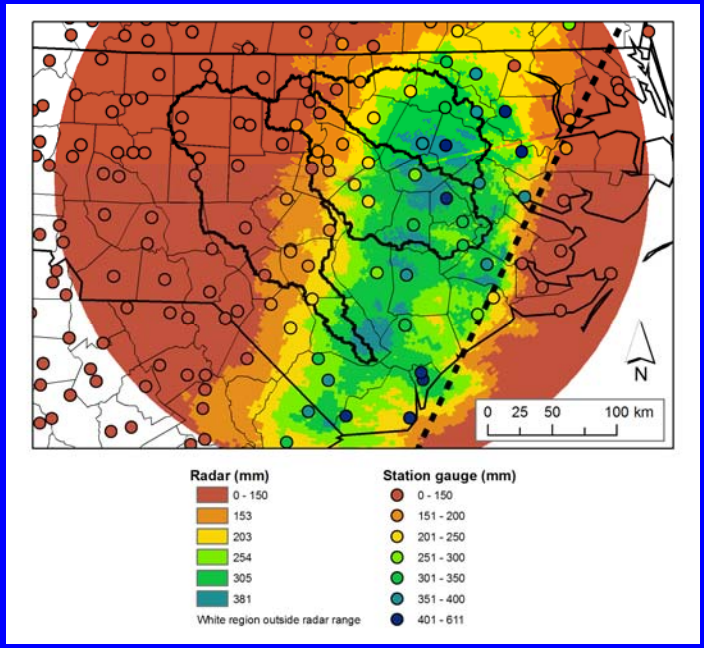
Data

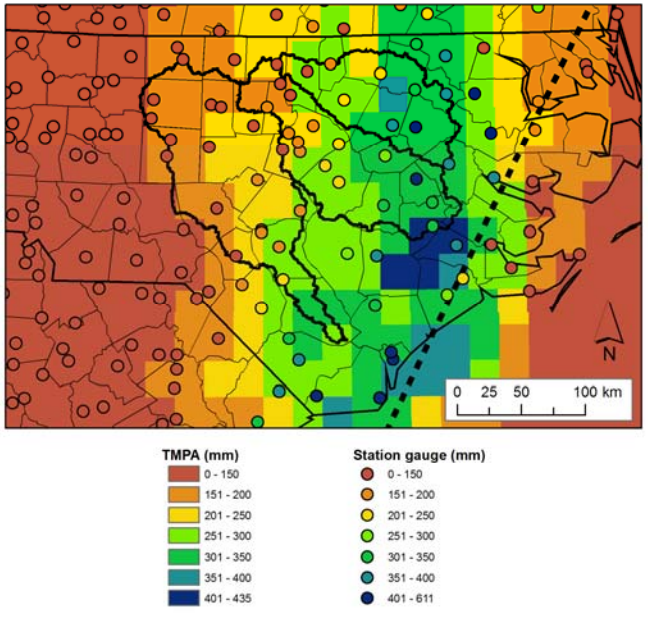
- Satellites:
  - Tropical Rainfall Measuring Mission
    - daily precipitation data
  - Global Precipitation Climatology Project
    - pentad precipitation data
  - Ship, buoy, satellite blended sea surface temperature data
- Kriged gauge data
- Radar storm total

Storm totals



Truth?





Summary

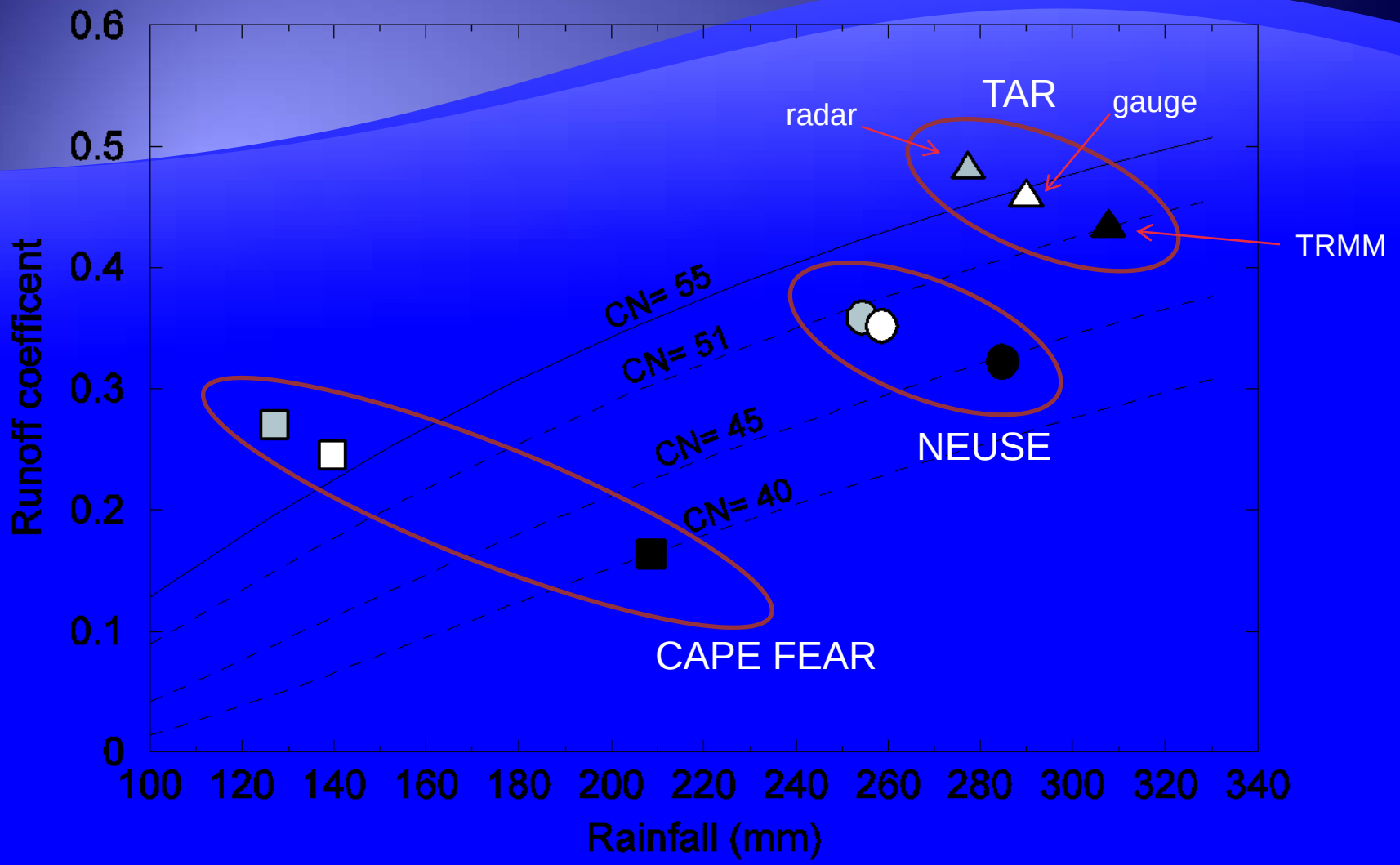
ATTRIBUTE	GUAGE – KRIGED Resolution: 0.25 km^2	RADAR (KRAX) Resolution: Variable, 0.1 km^2 to 150.6 km^2	TRMM Resolution: Approximately 625 km^2
Location of maximum storm total	Left of the storm track, near Brunswick and Edgecombe counties	West of the gauge maximum in a near continuous band from Cape Fear to Edgecombe county	Consistent with the gauge maximum, except additional maximum over Lenoir county
Discussion	**Location of the bulk of the precipitation is consistent with other published reports. Maxima in kriged analysis are dependent on the gauge locations.**		
Maximum storm total	593 mm	381 mm	435 mm
Discussion	**Minimum in the radar analysis is likely due to a) reporting storm totals in coarse increments of 0.5 to 2.0 inches; b) range-dependent biases.**		
Extent of storm totals > 150 mm (orange color)	From storm track west to Lee and Vance counties	Similar	Extending from the coast to the western edge of the Tar river basin
Discussion	**The TMPA is biased high overall.**		

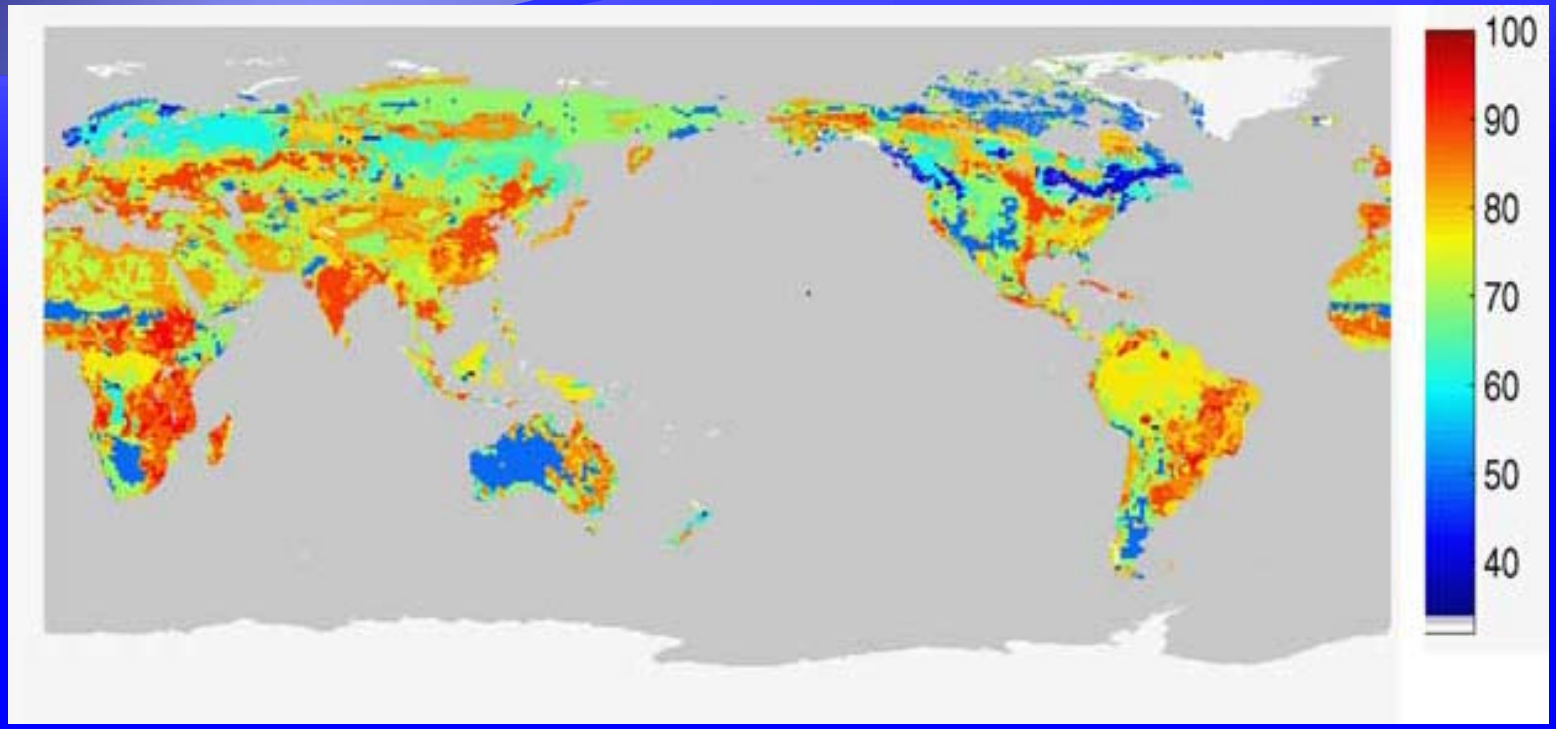
Basin totals

Basin	Volumetric rainfall x10^9 m^3 (bias % w/ gauge)			Discharge x10^9 m^3
	TRMM	RADAR	GAUGE	USGS
Tar - Greenville	2.12 (+6%)	1.91 (-5%)	2.00	0.92
Neuse - Ft. Barnwell	2.88 (+10%)	2.57 (-2%)	2.61	0.92
Cape Fear - Kelley	2.83 (+49%)	1.73 (-9%)	1.90	0.47

Curve numbers

- Curve numbers are based on empirical rainfall-runoff relationships
- $Q = (P - 0.2S)^2 / (P + 0.8S)$ and $CN = 1000 / (S + 10)$; where Q = discharge, P = precipitation, S = maximum retention, and assuming initial abstraction is 20% of S.
- CN 55, which fits the gauge and radar data reasonably well represents woodlands in good hydrologic condition. TMPA curve numbers are lower. Thus, if we had global CN numbers, they could be adjusted to account for the difference
- Hong et al. (2007) extended this work by deriving global CN numbers from remotely sensed data sets of soil and land use.

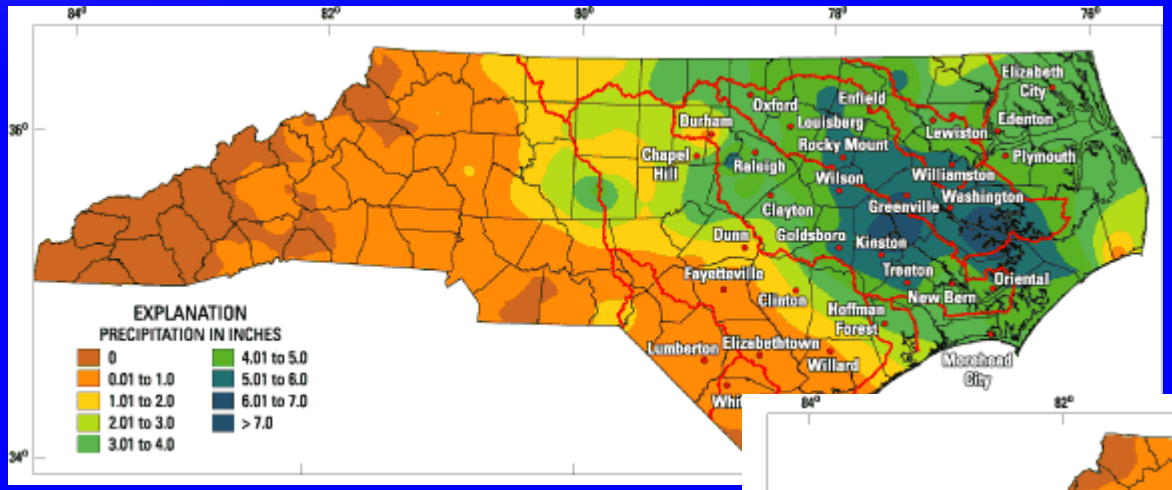

0.6
0.5
0.4
0.3
0.2
0.1
0
Runoff coefficent
100 120 140 160 180 200 220 240 260 280 300 320 340
Rainfall (mm)
CN= 55
CN= 51
CN= 45
CN= 40
radar
TAR
gauge
TRMM
NEUSE
CAPE FEAR



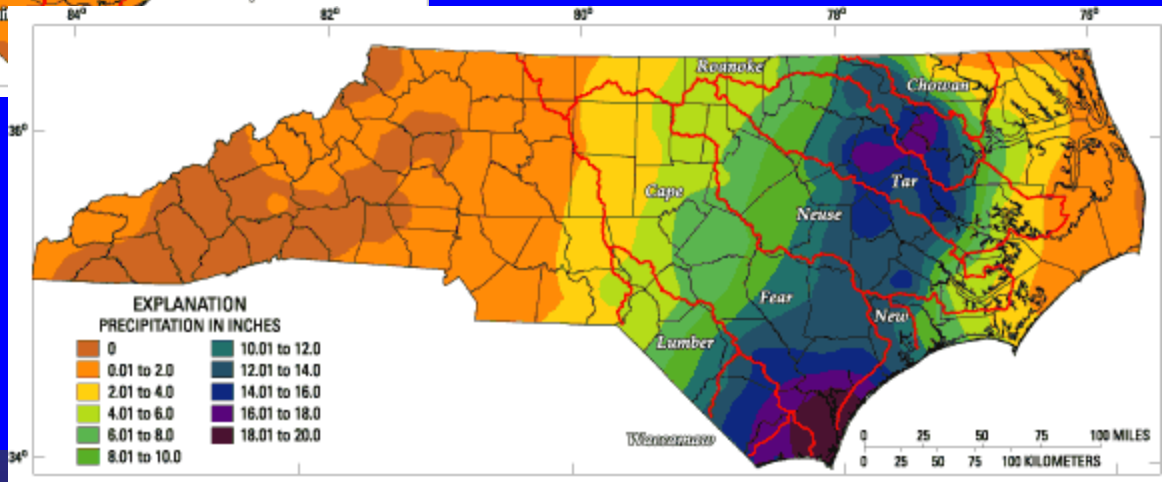
Hong et al. (2007)

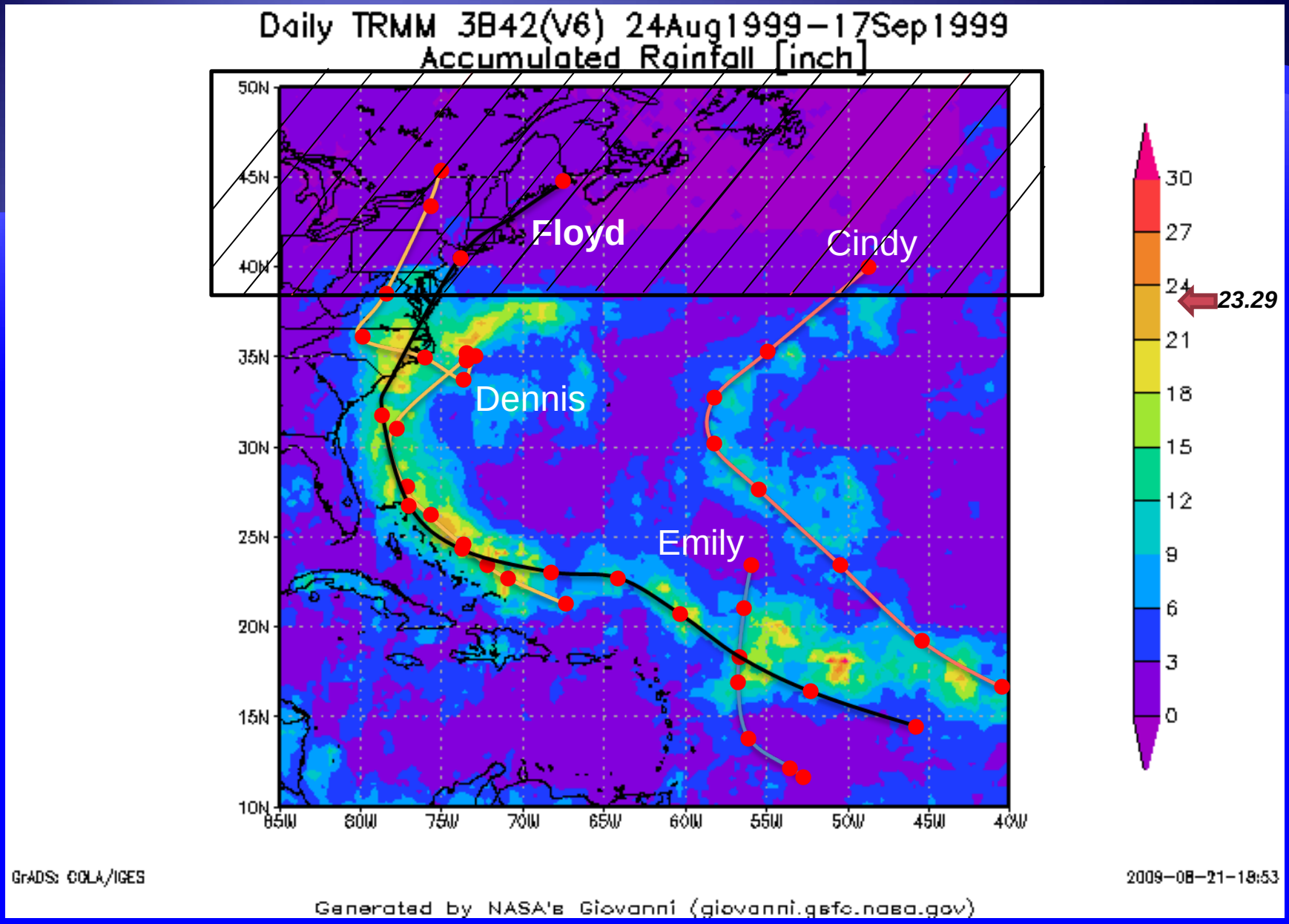
Have tropical cyclones been feeding more extreme rainfall?

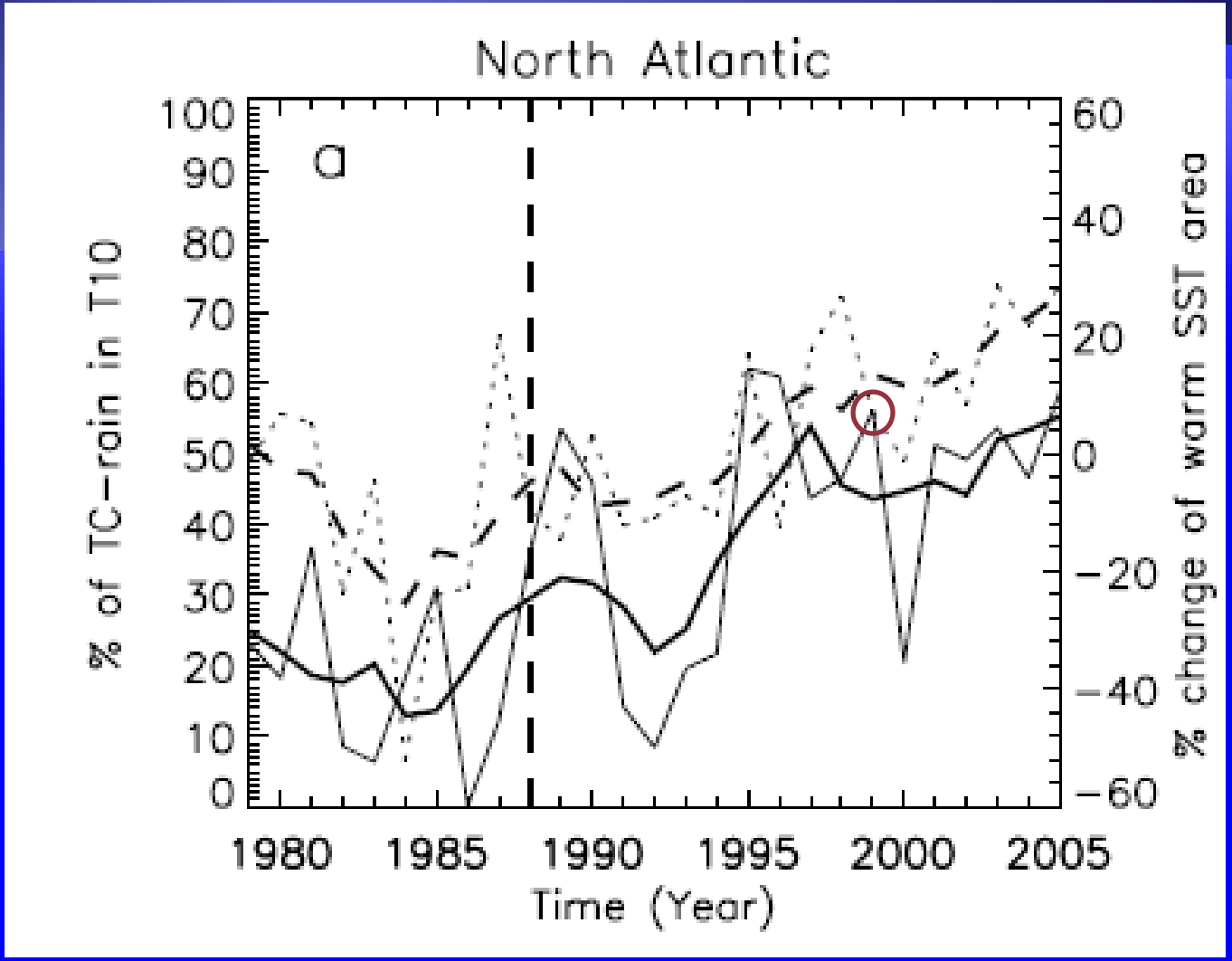
- (Shepherd et al. 2007, Lau et al. 2008)



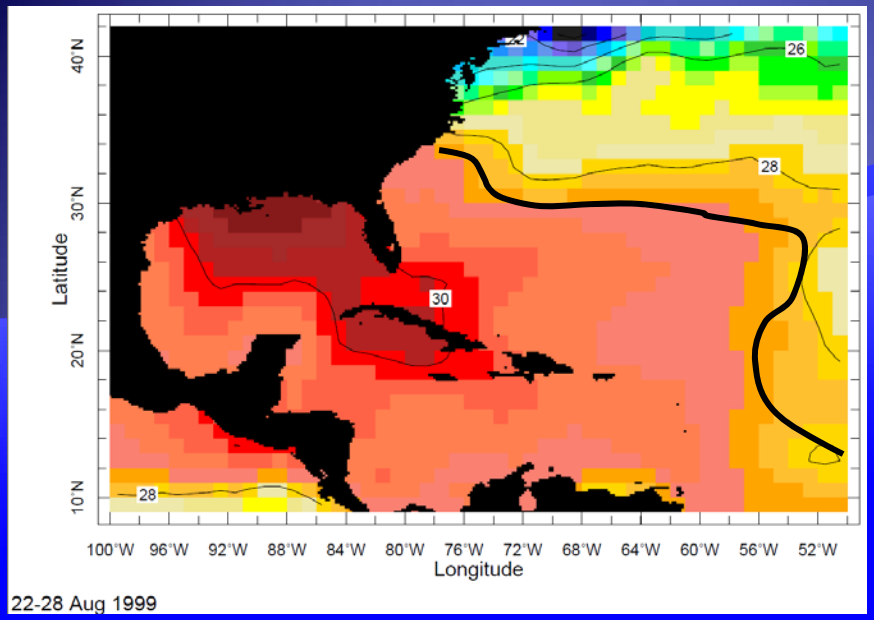
Greenville received a total of 23.29 inches of rain from 24 August to 17 September



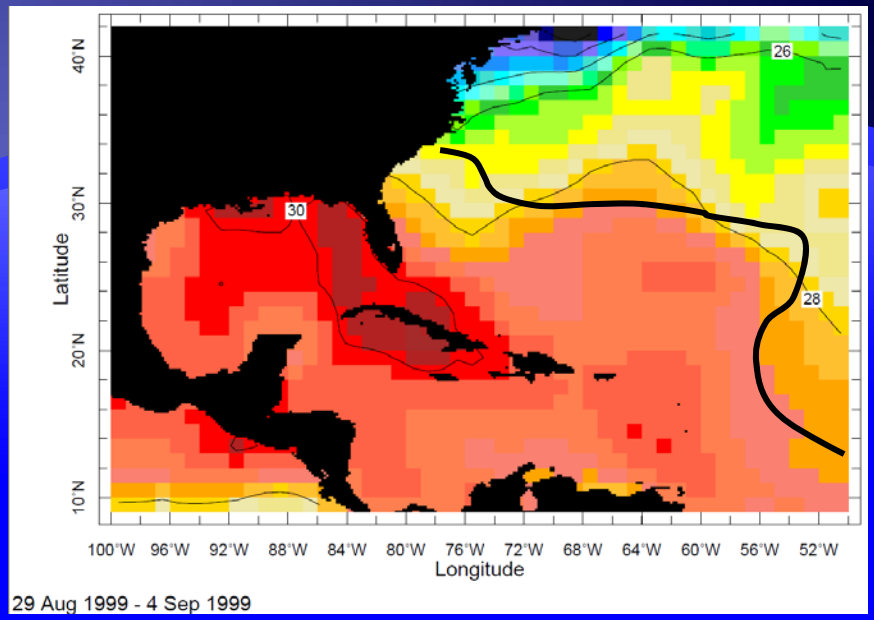

Daily TRMM 3B42(V6) 24Aug1999–17Sep1999
Accumulated Rainfall [inch]
Floyd
Cindy
Dennis
Emily
23.29
30
27
24
21
18
15
12
9
6
3
0
50N
45N
40N
35N
30N
25N
20N
15N
10N
85W
80W
75W
70W
65W
60W
55W
50W
45W
40W
GrADS: COLA/IGES
2009-08-21-18:53
Generated by NASA's Giovanni (giovanni.gsfc.nasa.gov)



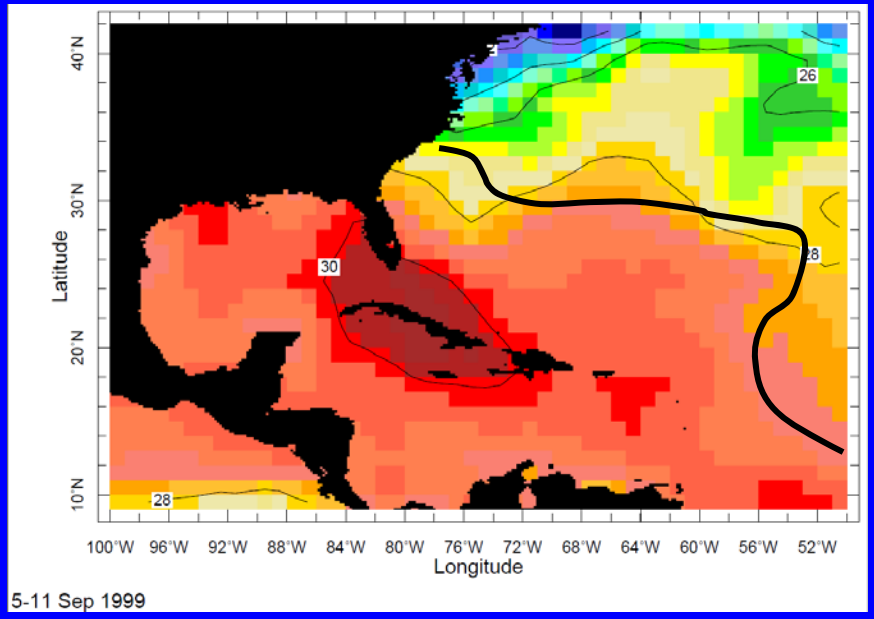
Time variation of cumulative extreme TC rainfall to total rainfall in the top 10 percentile of observations from the Global Precipitation Climatology Project pentad rainfall product (solid line). Dotted line shows the normalized anomaly in percentage of warm pool area (> 28 C) over Jul-Aug-Sep-Oct-Nov season for each year (Lau et al. 2008).



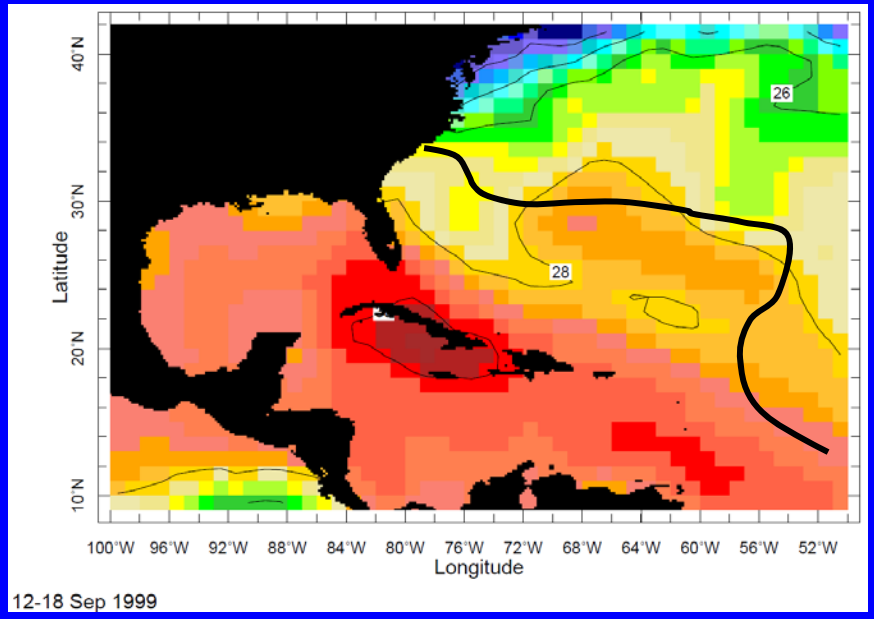
22-28 Aug 1999



29 Aug 1999 - 4 Sep 1999



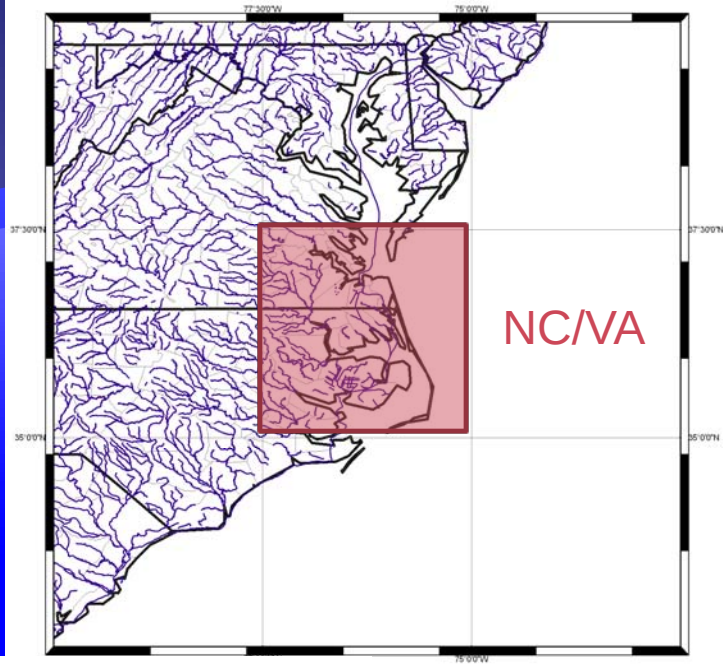
5-11 Sep 1999

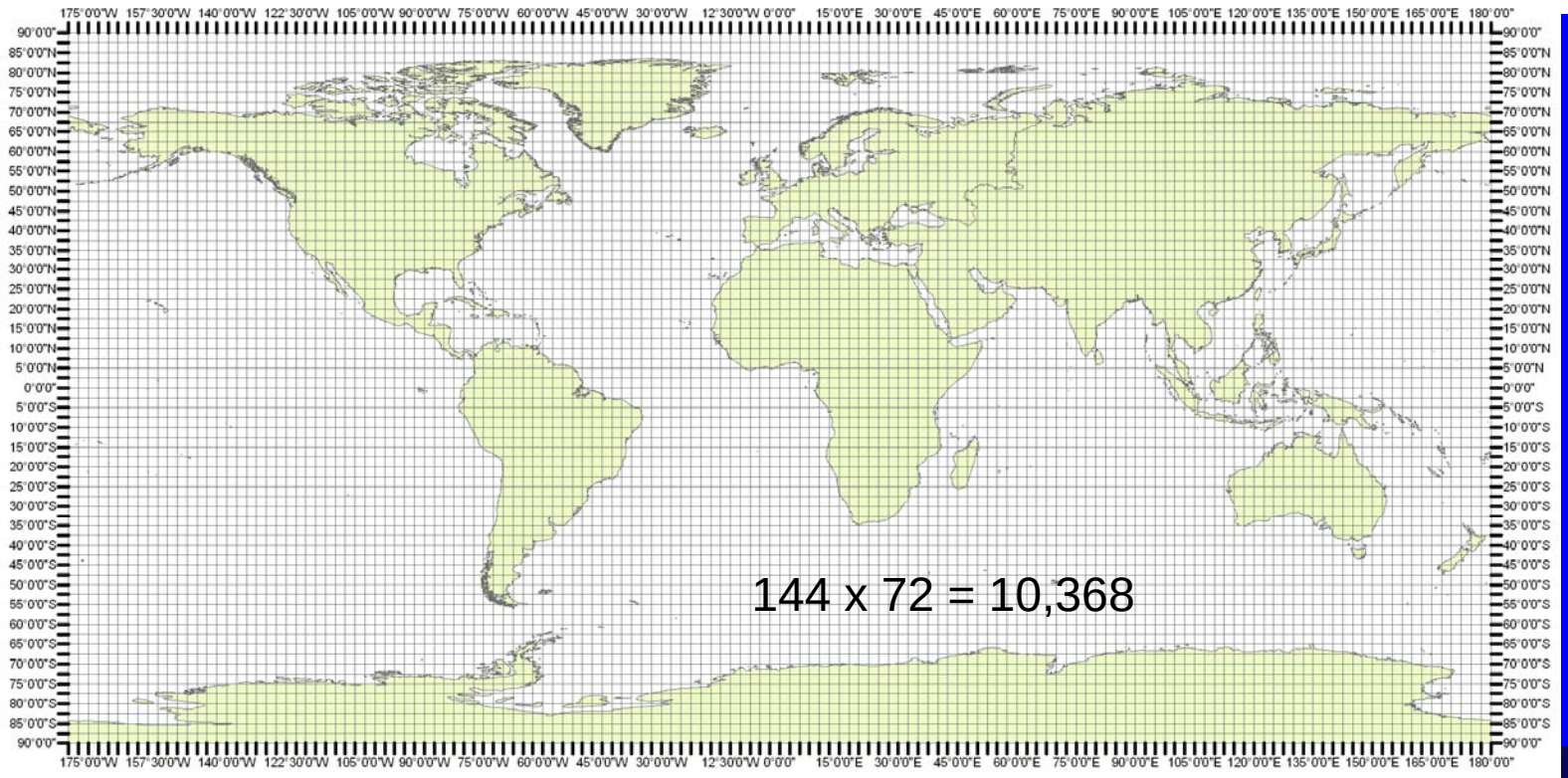


12-18 Sep 1999

How does NC/VA rank ?

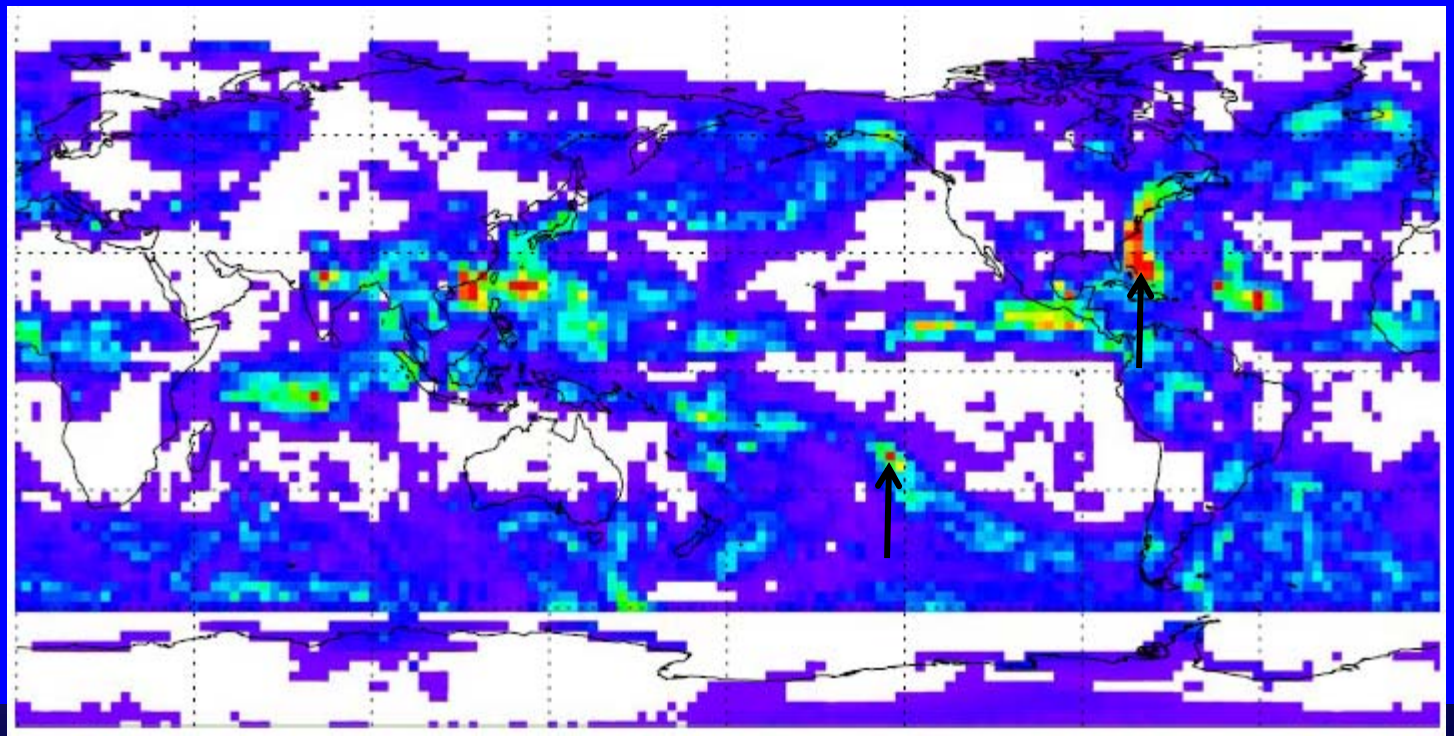
- GPCP pentad September 13-17 1999
  - 38.6988 mm/day (or 7.6 inches)





How does NC/VA rank?

- NC/VA was the 4th rainiest grid box for the pentad September 13 to 17, 1999
- More rain occurred near the Bahamas, associated with Floyd, and in the southeastern Pacific



Is this unusual?

- NC/VA has only been ranked in the top ten 3 pentads out of 2117 (from 1979 to 2007)
  - 2nd : Aug 24-28 2006 associated with Hurricane Ernesto
  - 4th : Sep 13-17 1999 associated with Hurricane Floyd
  - 5th : Sep 23-27 1985 associated with Hurricane Gloria

Future Work

- Rankings are an objective and homogeneous measure of "relative climate change"
- The methodology can be used to answer the question: Is a location contributing more or less to global extreme weather?
- Climate change results will be presented at the Carolinas and Virginia Climate Conference October 20-21, 2009

Conclusions

- Best agreement between Gauge*, Radar, and Satellite over the Tar River Basin:
  - 1.91 to 2.12 km^3 of water (larger than Lake Norman)
- Tropical Rainfall Measuring Mission satellite shows large swath of precipitation in the Atlantic of the same magnitude as recorded in North Carolina (Cindy + Dennis + Emily + Floyd)
- Floyd rainfall was extreme in a global sense
- NC/VA achieved similar rankings in the past from August to September associated with tropical cyclones. Could these rankings be helpful for projecting into the future?