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Development of Tropical Cyclone Rainfall Climatology and Persistance (R-CLIPER) Model

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INTRODUCTION:

- Tropical cyclones (TC) pose significant quantitative precipitation forecast (QPF) problem as evidenced by tragic loss of life and property from rain in Hurricanes Mitch (1998), Floyd (1999), and TS Allison (2001).
- Over last 30 years majority of TC-related deaths are caused by flooding (Rappaport 2000).
- Threat of flooding is a function of rain rate (R) and duration, making storm size (D) and motion (Vs) critical parameters.
- Enhanced rainfall due to orographic forcing and/or interactions with mid-latitude frontal boundaries increase threat of flooding.

- Over open water simplest TC QPF is a climatology and persistance (CLIPER) model that predicts peak storm total rain (R_{max}) as:

$$R_{max}=RDV_s^{-1}$$

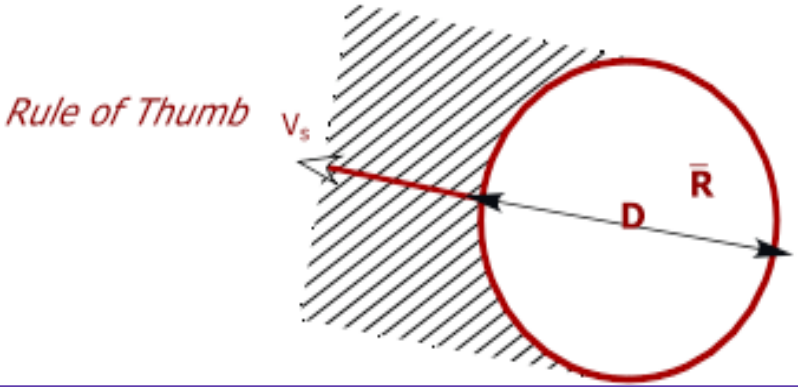
integral of R along line (D) with V_s.

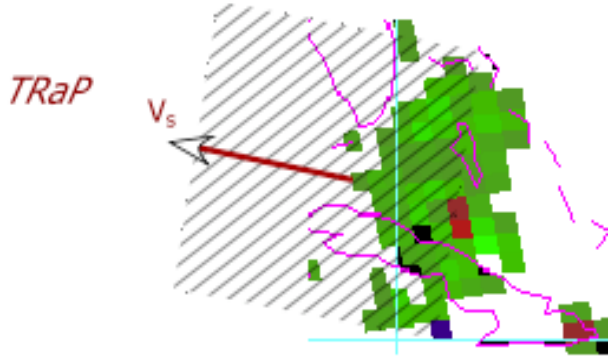
- Originated in late 1950s as Kraft's "rule of thumb" where:

$$R_{max}=130.8\ V_s^{-1}$$

where R_{max} in cm, V_s in m s^{-1}, and climatological R=0.98 cm h^{-1} and D=500 km.

- Tropical Rainfall Potential (TRaP) (Ferraro et al 1998) uses similar approach, but with satellite R-estimates projected along track
- Note these techniques have no adjustments for storm intensity, topography, or other parameters.





GOAL:

- Improve understanding of tropical cyclone (TC) rainfall (R) by developing a rain climatology of TCs, globally,
- Develop a methodology to improve forecasting of TC rain distributions.

DATA:

- R estimates from TMI version 5 for 245 storms from December 1997 to December 2000, globally, yielding 2121 events (observations), in TCs ranging from TD to category 5 intensity.

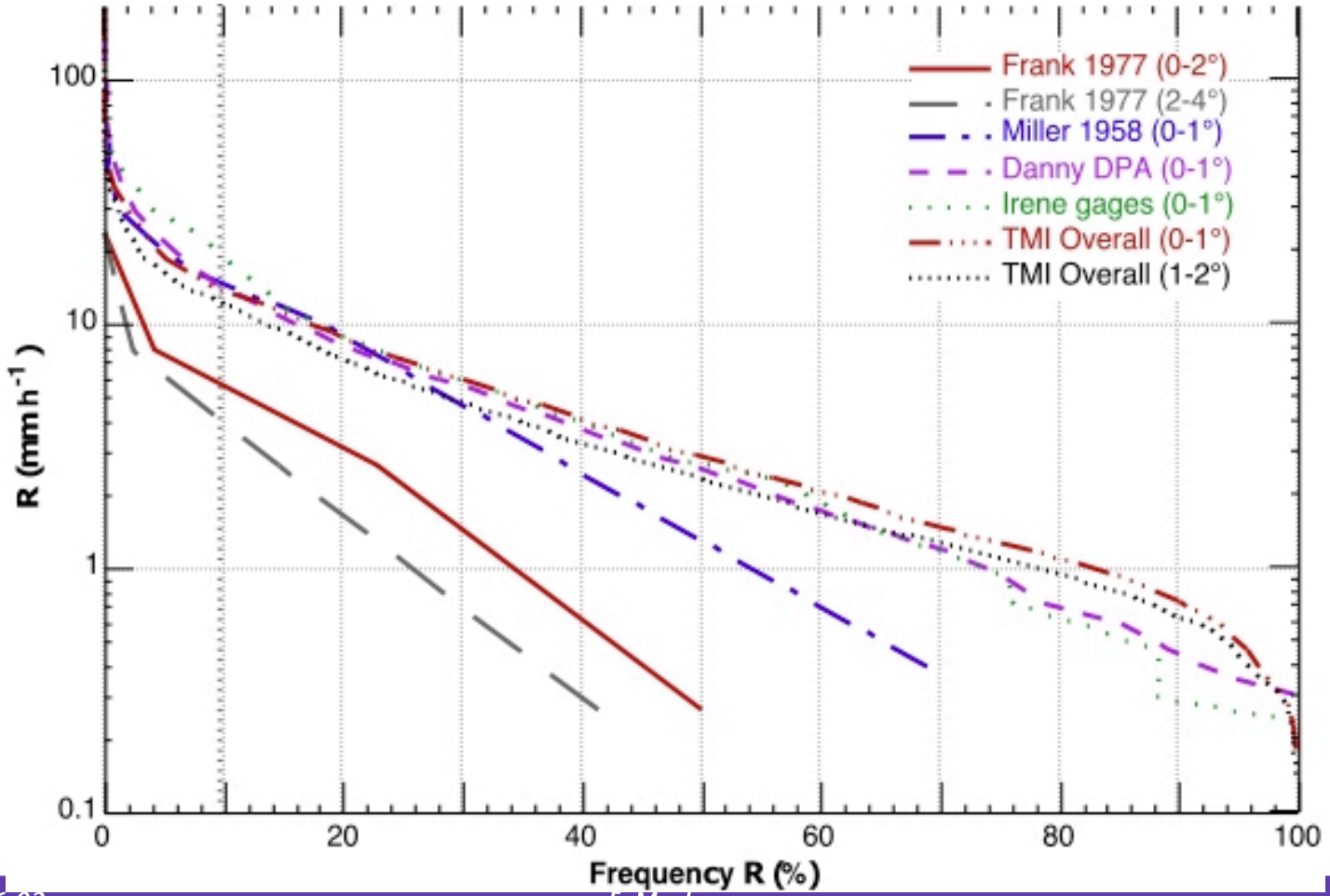
1998-2000 TMI events by Intensity

Storm Intensity	*Events*	*%*
TD/TS	1361	64
Category 1-2	548	26
Category 3-5	212	10
Total	**2121**	

- 560,000 hourly rain gauge estimates in 46 landfalling hurricanes in the U. S. from 1948-2000

RESULTS:

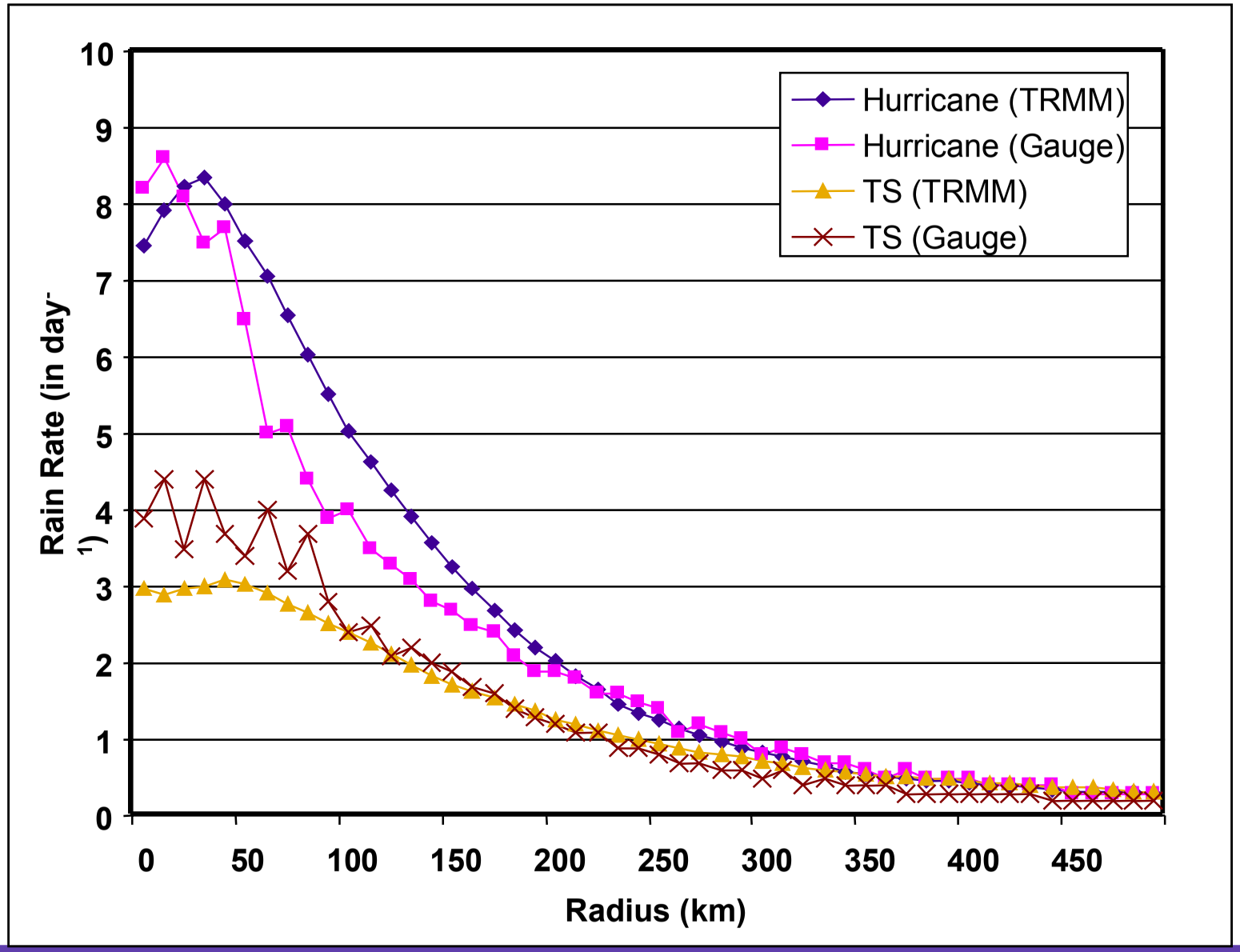
- Comparison of TMI and gauge to TC R probability distributions by Miller (1958) and Frank (1977) shows fairly good agreement.
- Comparison of TMI with recent WSR-88D and recent gauge estimates shows very good agreement.



R-CLIPER Model

(Rain Gauge vs TMI Version)

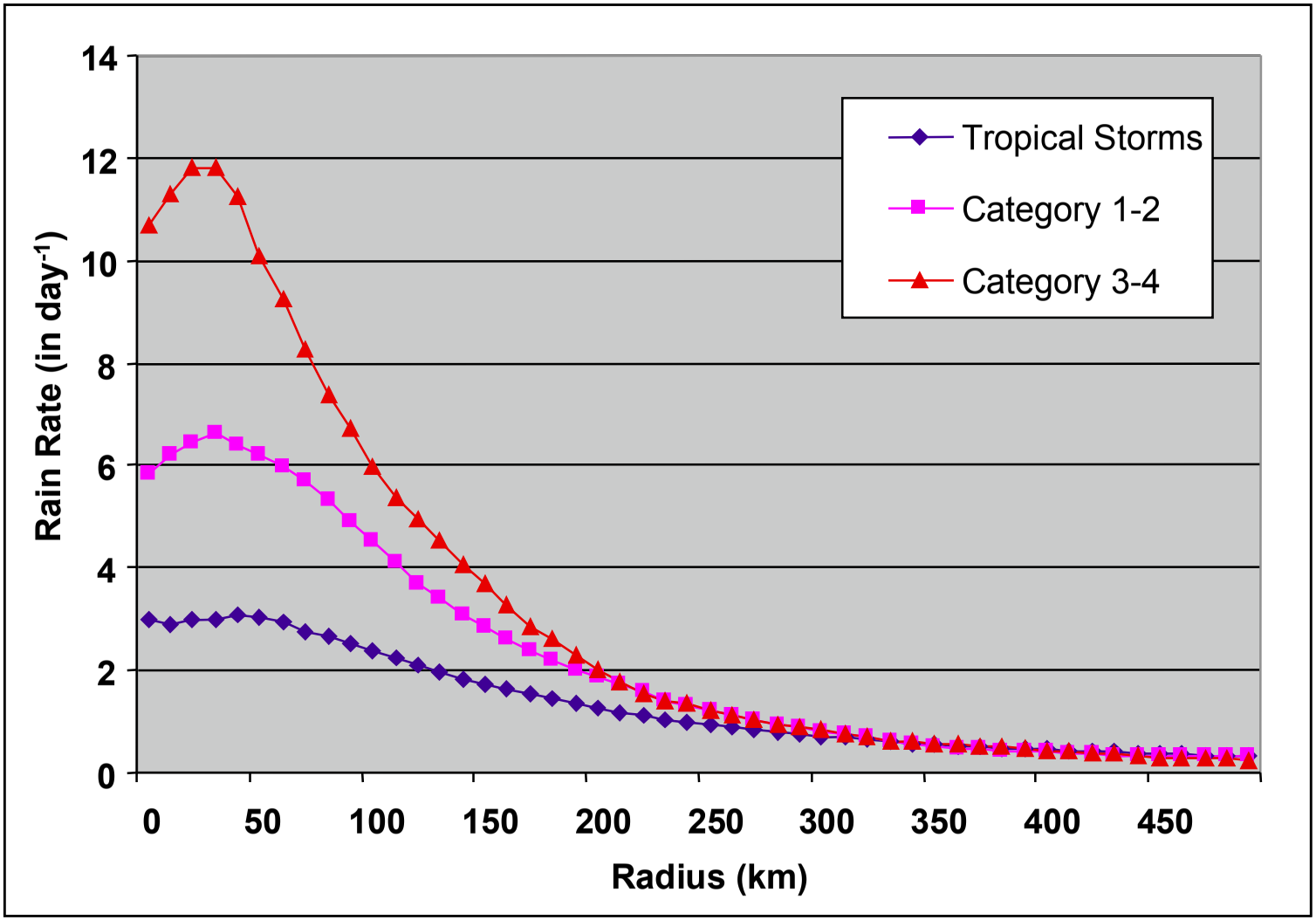
(Rain gauge data for storms within 6 h of landfall)



R-CLIPER Generalization using TMI Data

- Gauge data insufficient to stratify by intensity
  - Gauge R-CLIPER forecasts depends only on track
- Use TRMM data to determine R versus intensity (particularly after landfall).
  - Replace gauge R with TRMM R.
  - TRMM R-CLIPER depends on track and intensity.

Current TRMM R-CLIPER



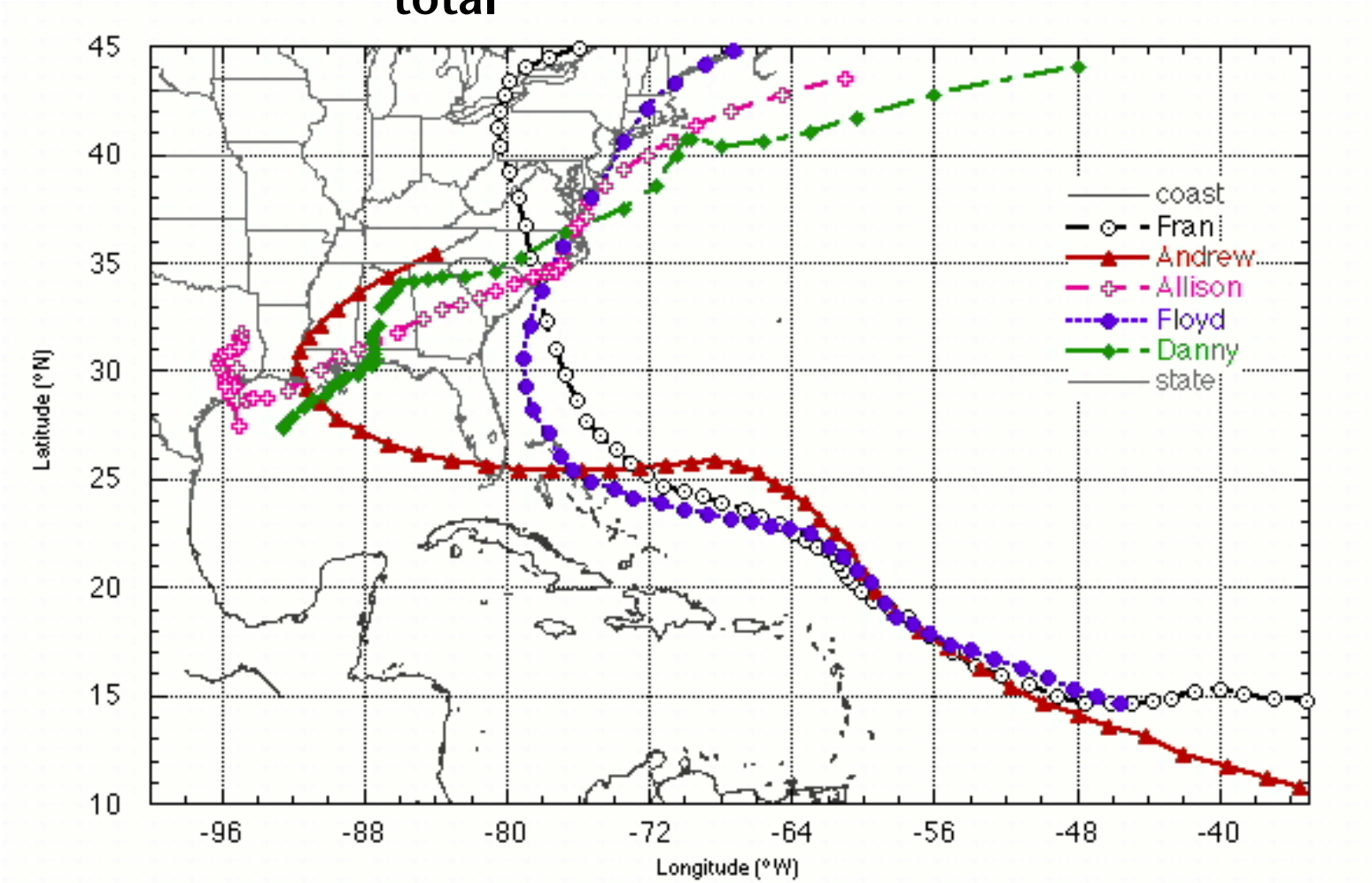
Functional Form: $R(r) = (R_0) + (R_m-R_0)(r/r_m) \quad r<r_m$

$= R_m\exp(-(r-r_m)/r_e) \quad r>r_m$

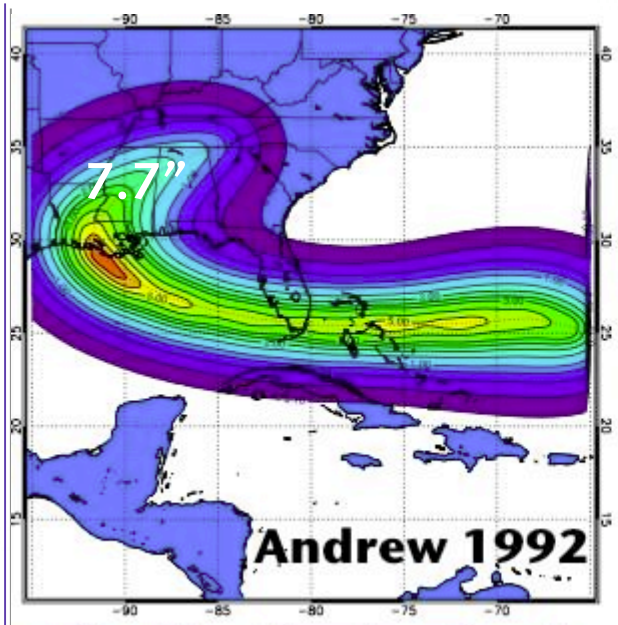
Free parameters R_0, R_m, r_m, r_e are functions of max winds

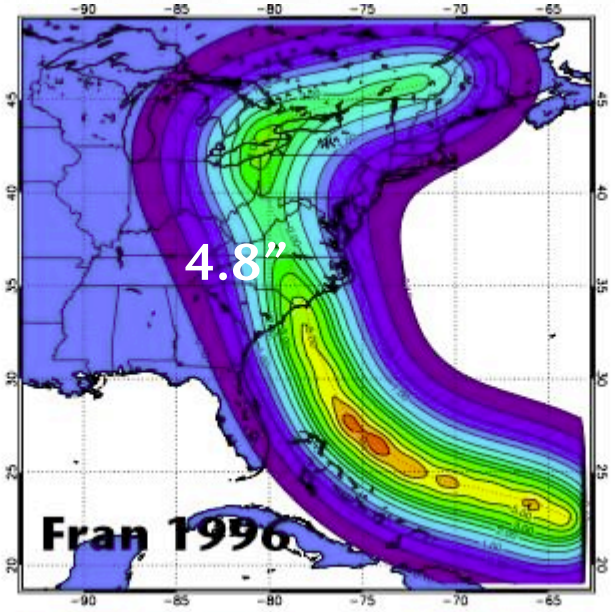
DIAGNOSTICS

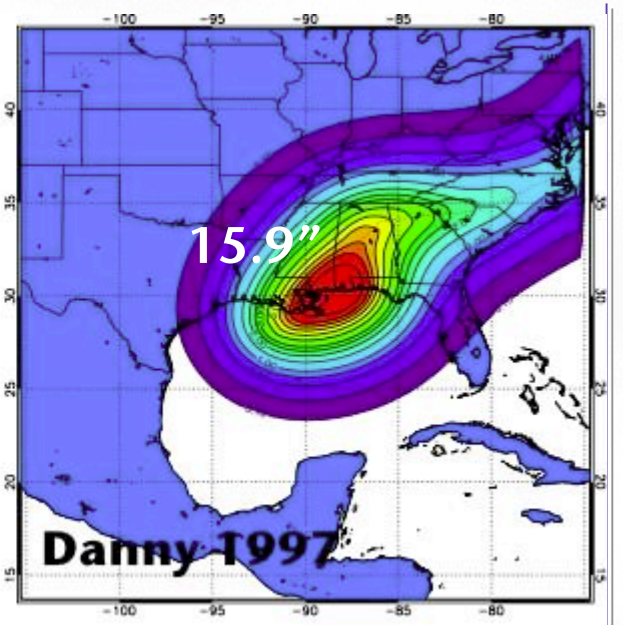
- Diagnostics run on 5 cases.
- Validate R_{total} and 24-h total rain.

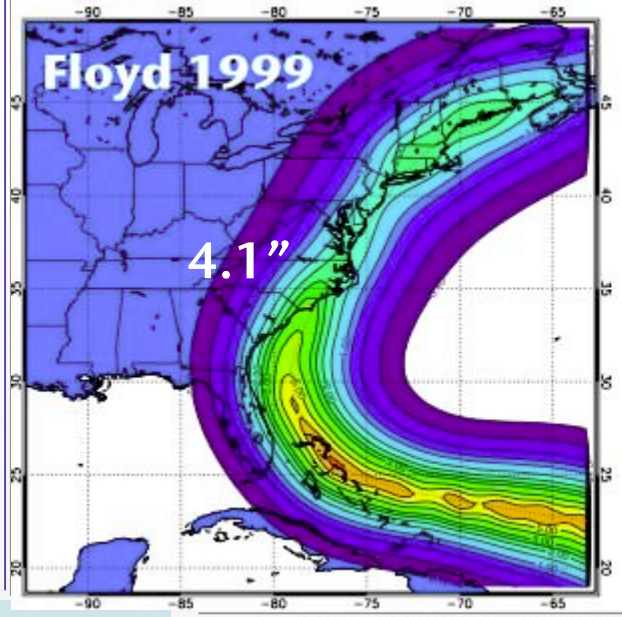


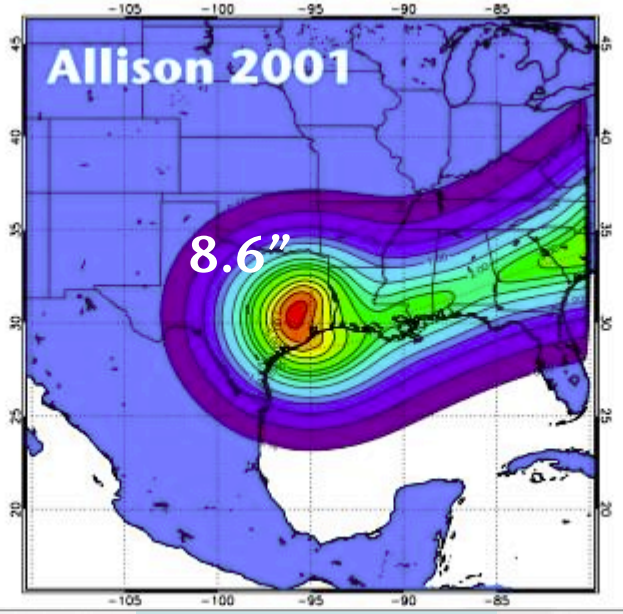
R-CLIPER Cases









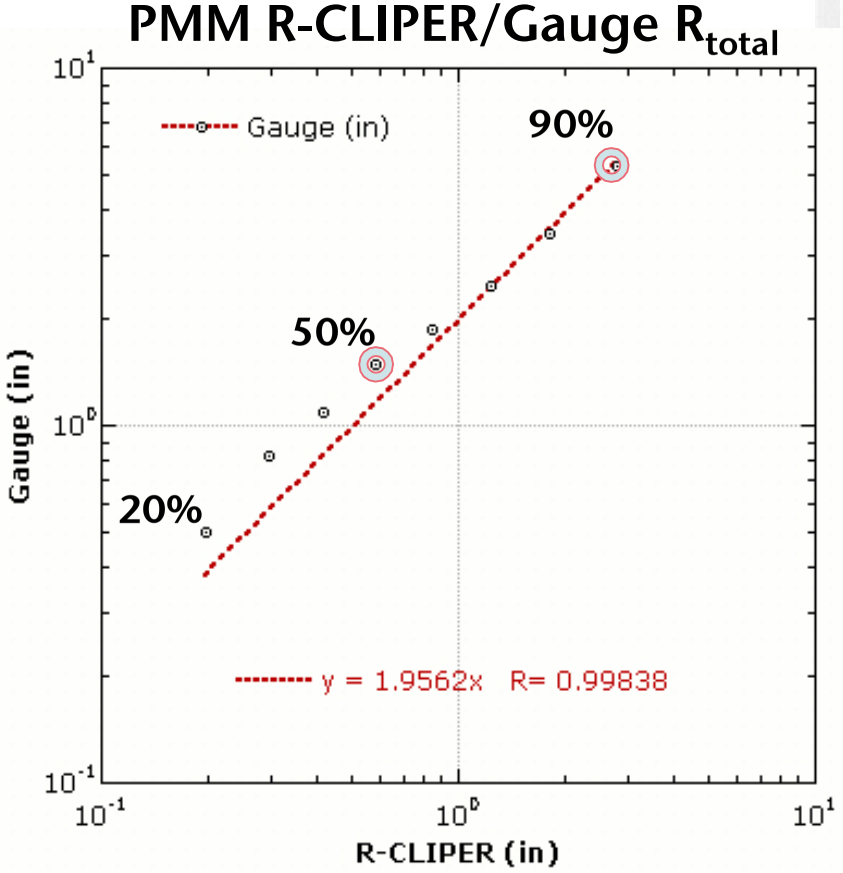


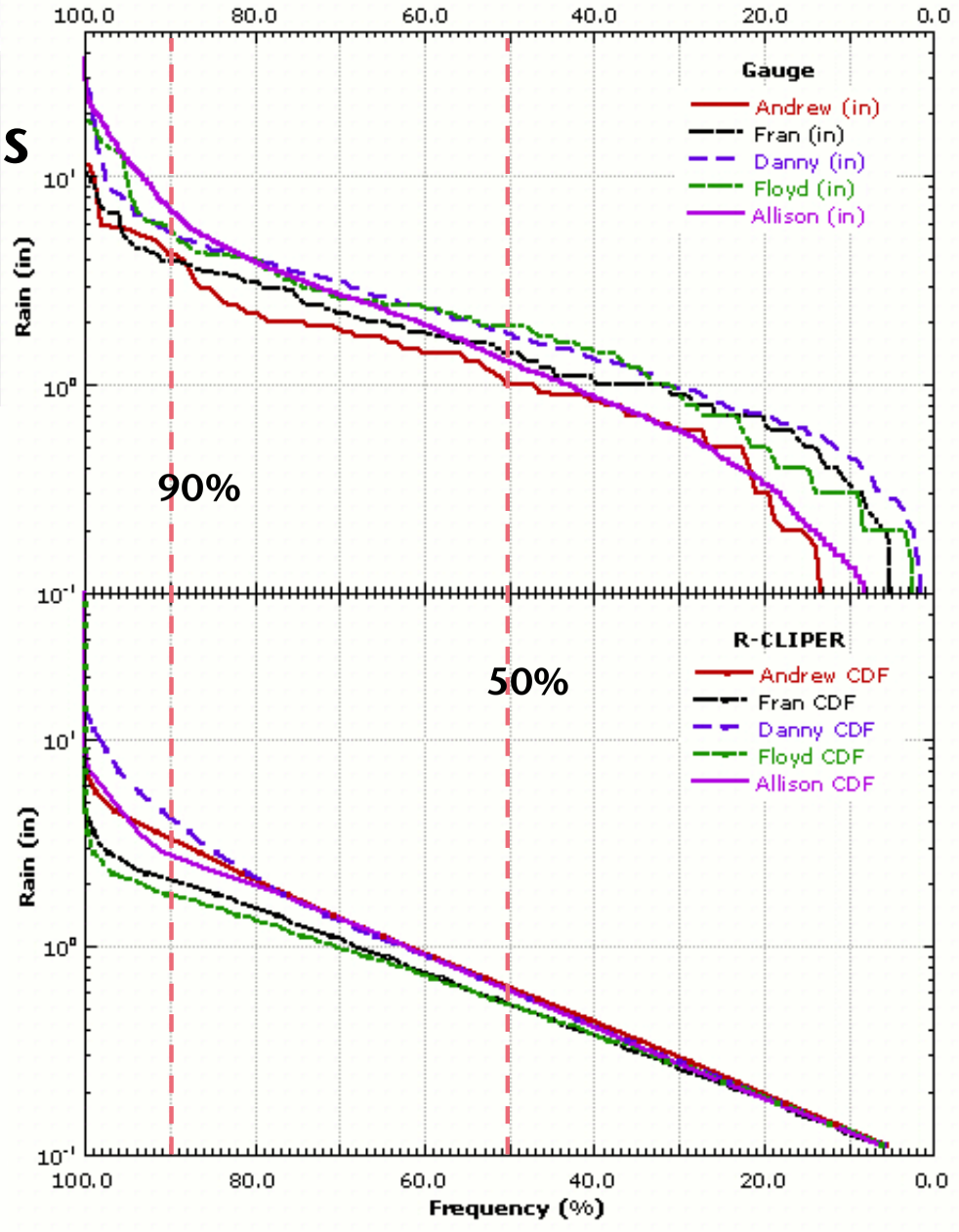
color contours denote R_{total} (inches, peak at landfall listed)

Position and intensity from best track (6 h)

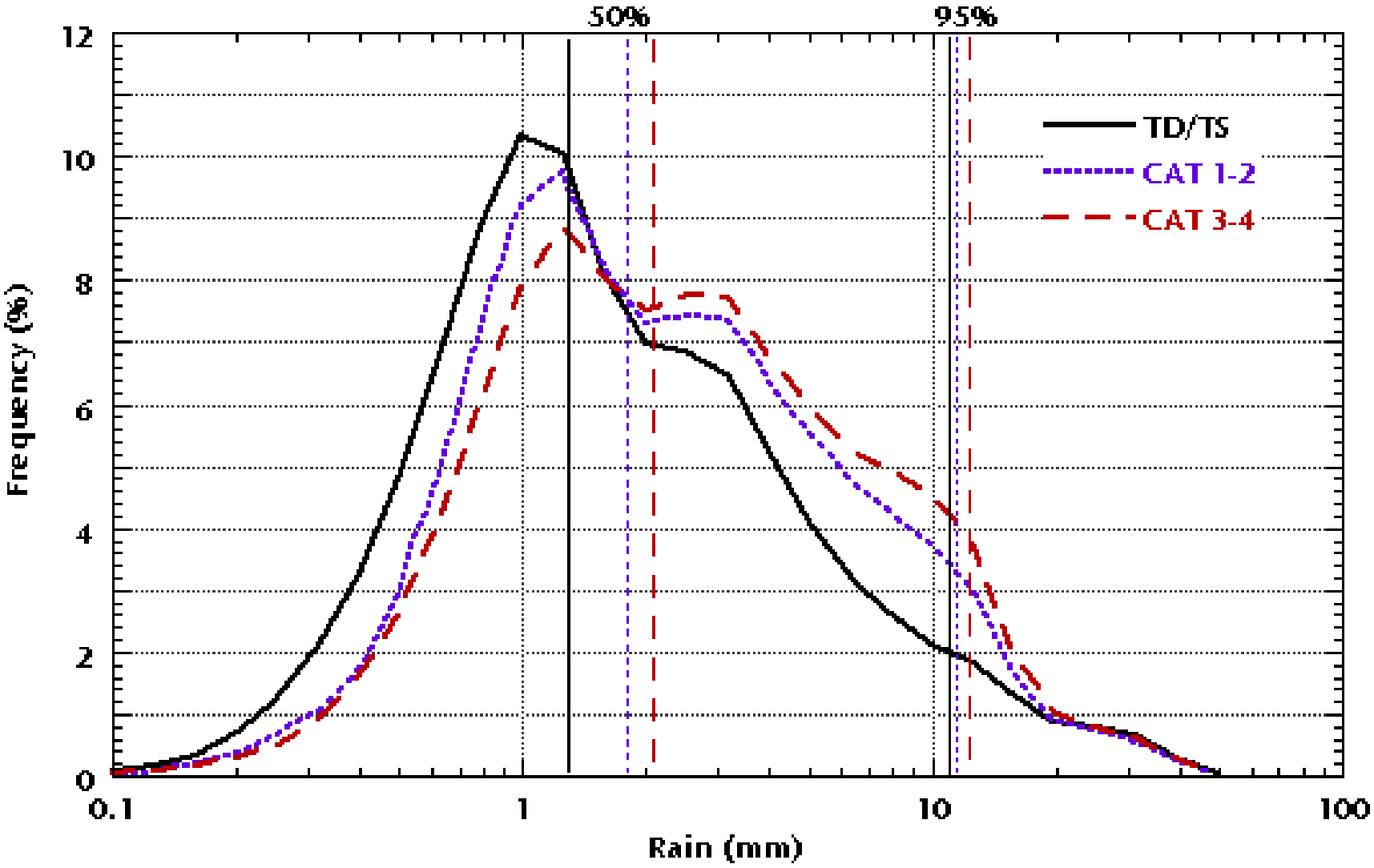
R-CLIPER Cases

- R-CLIPER underestimates area of R_{total} by factor of 2 using CDF.



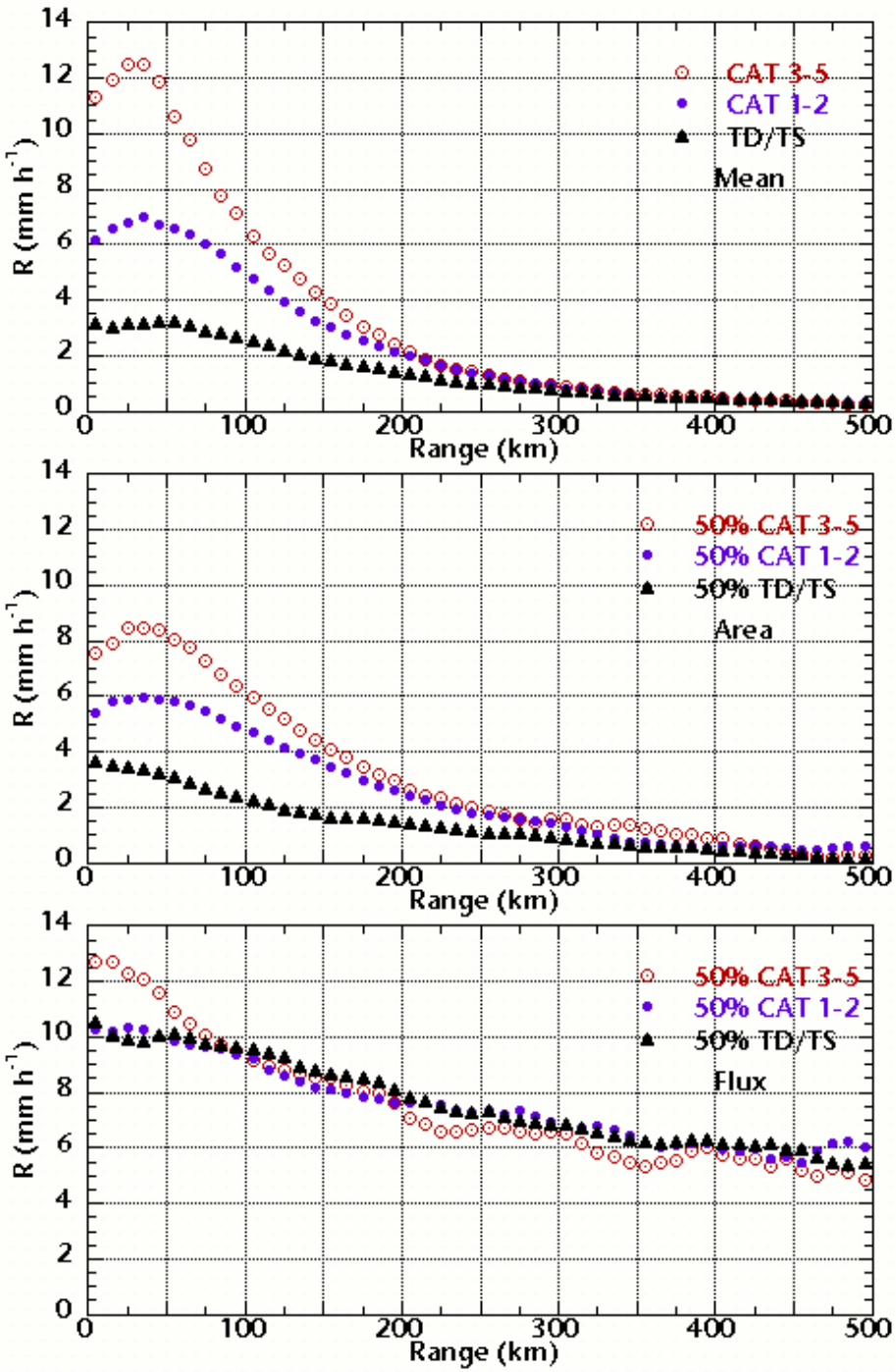


TMI PDF of R


50%
95%
12
10
8
6
4
2
0
Frequency (%)
0.1
1
10
100
Rain (mm)
TD/TS
CAT 1-2
CAT 3-4

Measures of R PDF

- R-CLIPER uses mean - not best measure of PDF (log-normal) - shows intensity influence
- Other measures of PDF are median (50% area or flux) - area shows intensity influence, but flux does not.



TC QPF Questions

- What characteristic of PDF of R are we trying to predict, i.e., mean R, R_{max}, etc.?
- What is best measure of PDF of R to use to answer the question, i.e., mean, median, 90% of PDF?
- R-CLIPER can be tailored to address many questions.

Where Do We Go From Here?

- R-CLIPER provides benchmark for evaluation of other QPF techniques.
- Evaluate R-CLIPER on past storms to develop data products for hurricane specialists.
- Compare R-CLIPER forecasts to 6-h areal average rainfall amounts on HPC 1°X1° grid.
- Work with NHC and HPC to provide forecast track after landfall.