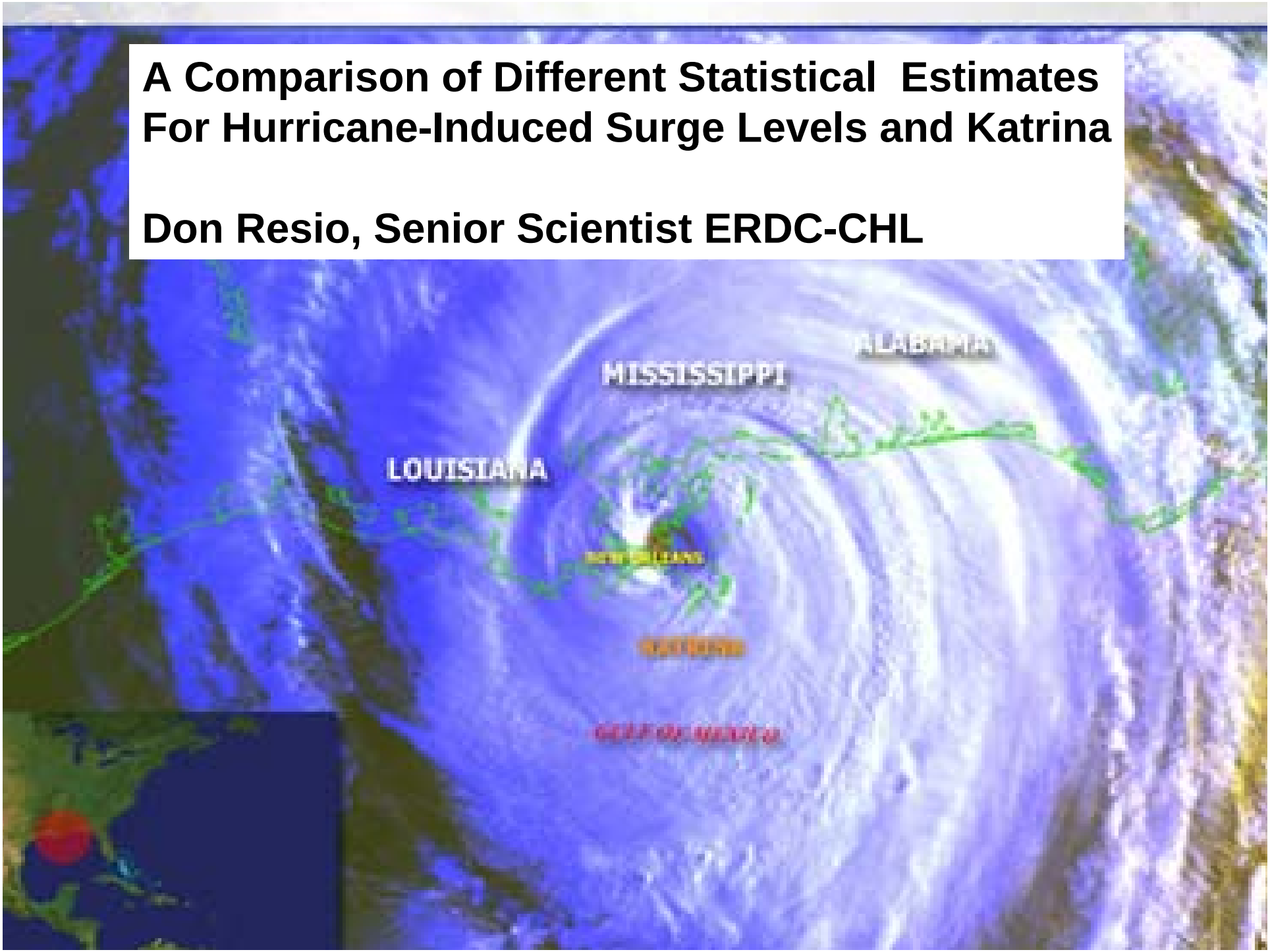
A Comparison of Different Statistical Estimates For Hurricane-Induced Surge Levels and Katrina

Don Resio, Senior Scientist ERDC-CHL



Methods for Estimating Water Level Probabilities

Historical Data Analysis

Design Storm Method – SPH/PMH

Joint Probability Method

Empirical Simulation Technique (EST)

Synthetic Storm Method (Empirical Track Method)

Current guidance

"Forecasting can be very difficult --- particularly when it involves the future."

Yogi Berra

SPH: "one that might be expected from the most severe combination of meteorological conditions that are considered reasonably characteristic of the region" (ex. Sep 1915 – upper 3/lower 4 – Katrina?)

1961 SPH max surge hts – Buras 12.4 ft, Shell Beach 14.4 ft

PMH: "one that may be expected from the most severe combination of critical meteorological conditions that are reasonably possible for the region. It has an infinite recurrence period" (no example given)

1961 PMH max surge hts – Buras 15.0 ft, Shell Beach 16.8 ft

Katrina significantly exceeded these PMH values (e.g. > 20 feet at Buras).

SPH: Historical Perspective

- Initial SPH formulated as part of flood protection design study for Lake Okeechobee, Florida 1954

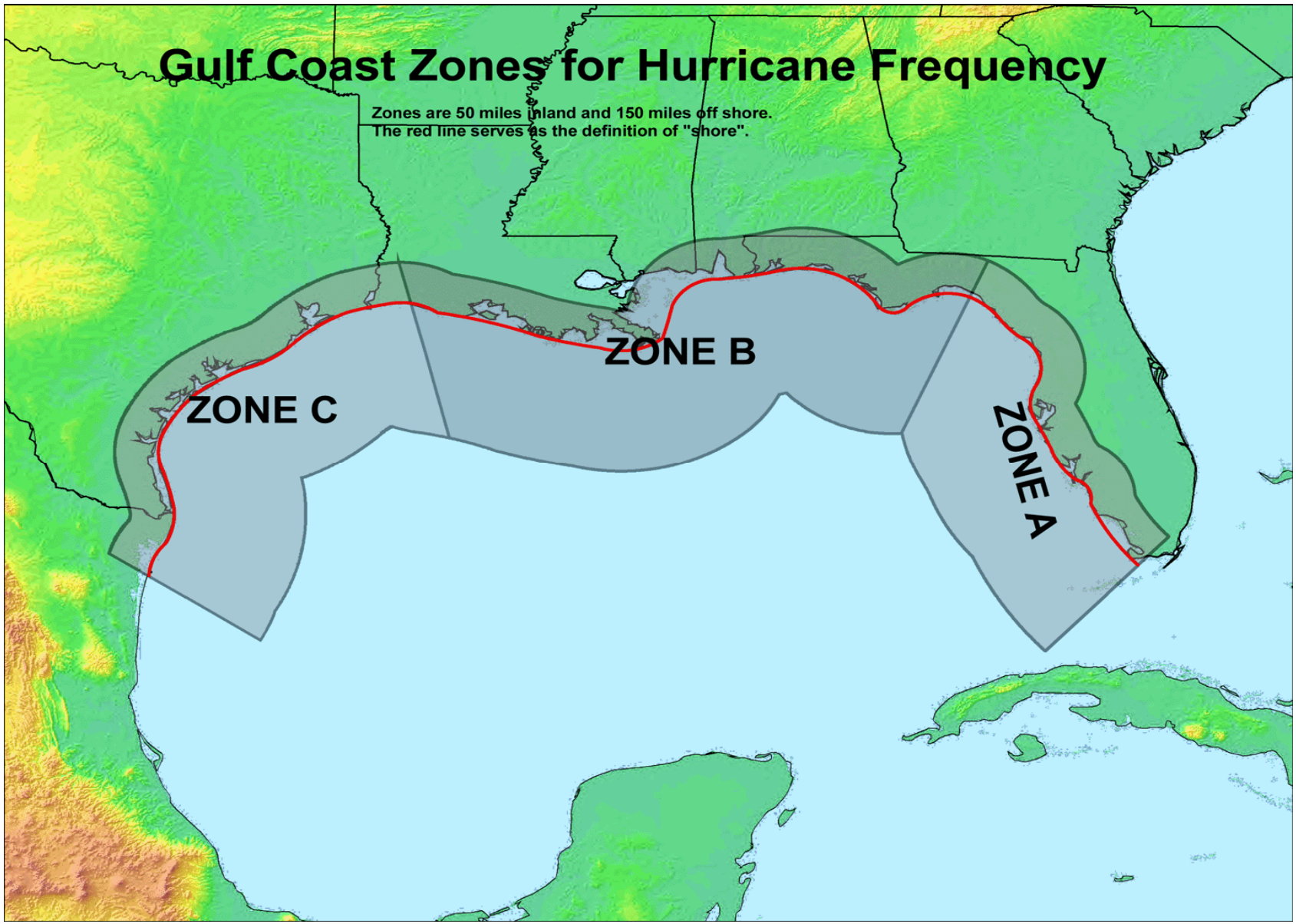
- US Weather Bureau in coordination with US Army Corps of Engineers developed generalized hurricane specifications for 3 zones within Gulf of Mexico (National Hurricane Research Project TR 33), 1959

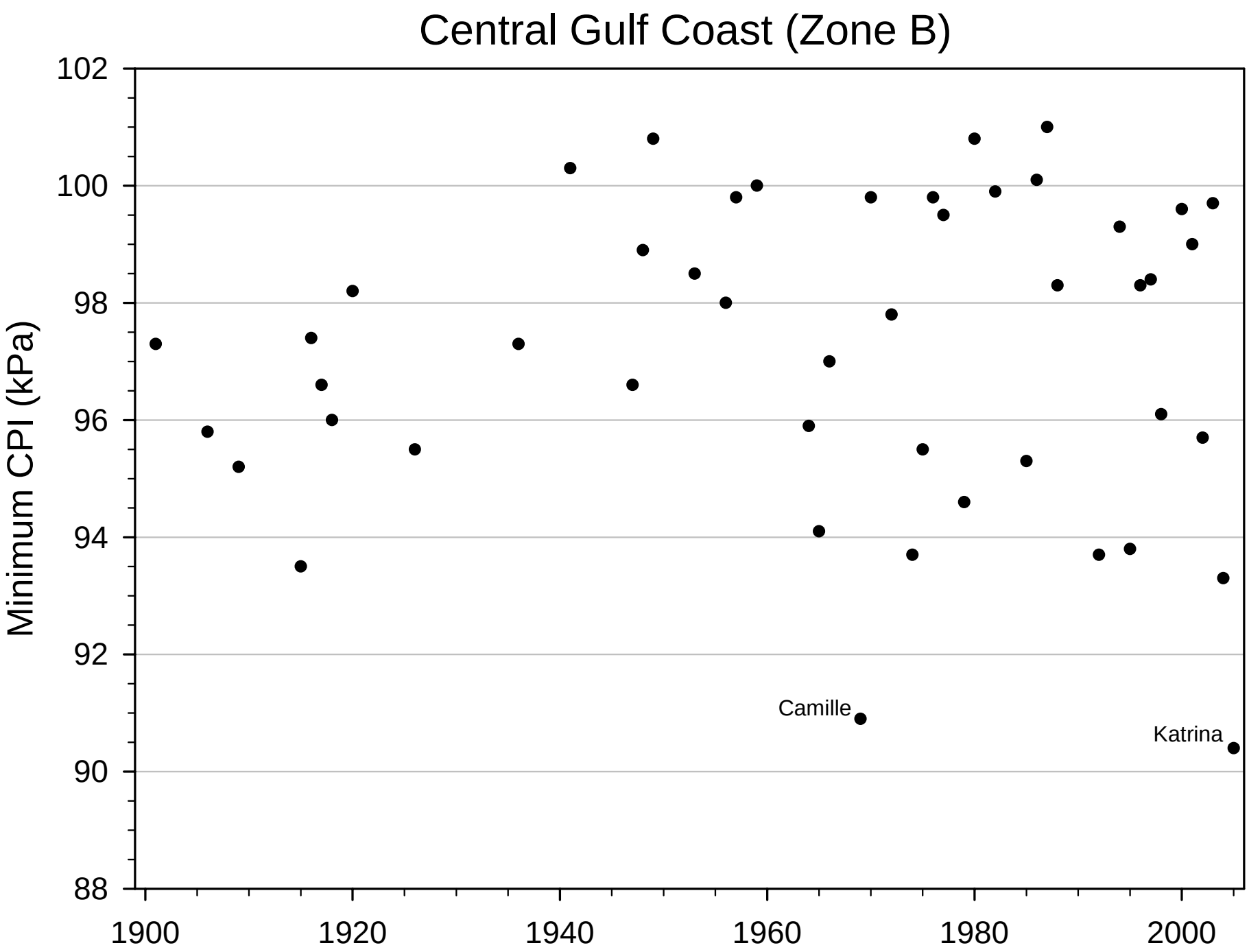
- Post-Hurricane Betsy update of wind field characterization but not Hurricane parameters, 1965, 1966

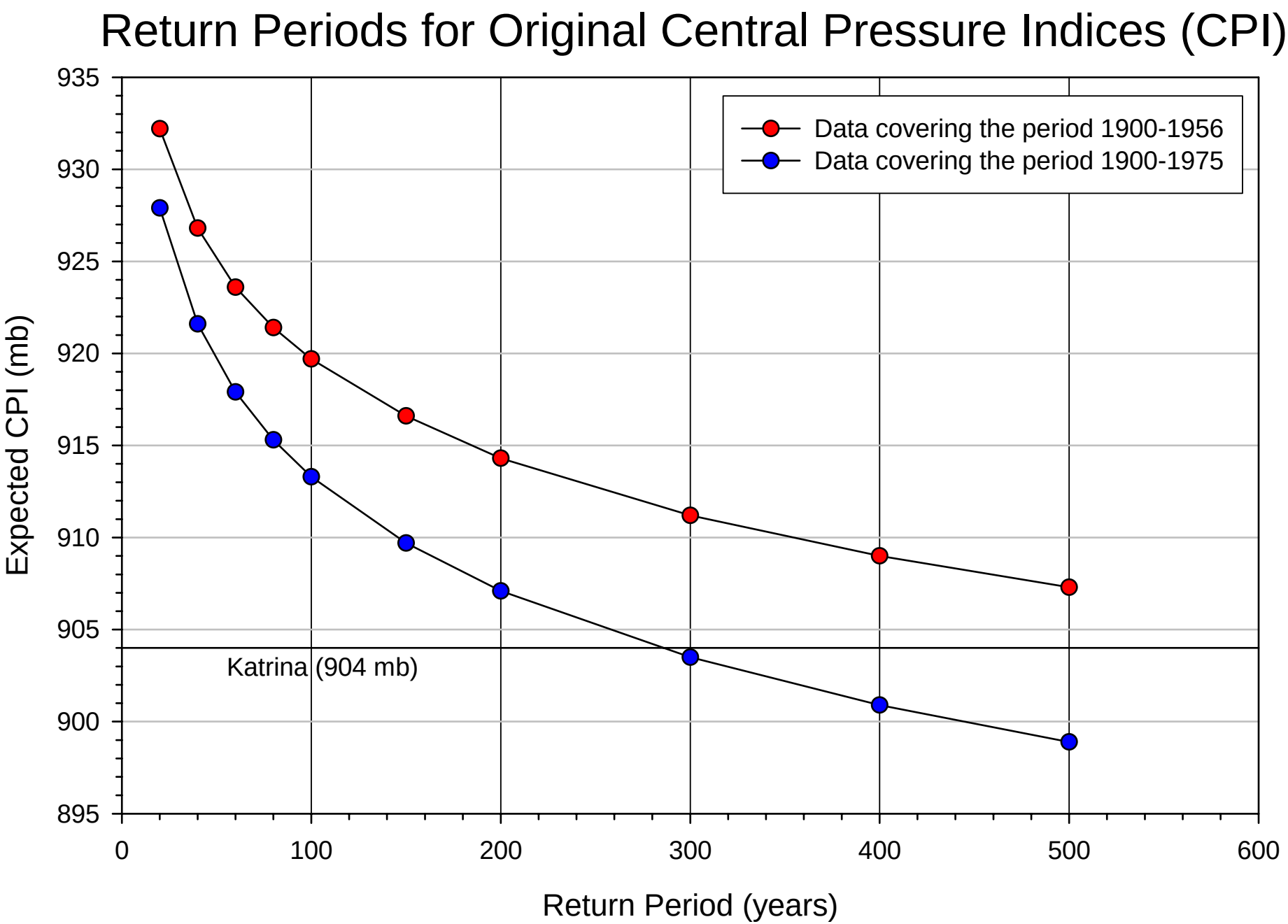
- Update of hurricane parameters NOAA NWS TR 23, 1975

- Update of hurricane parameters NOAA NWS TR 38, 1987

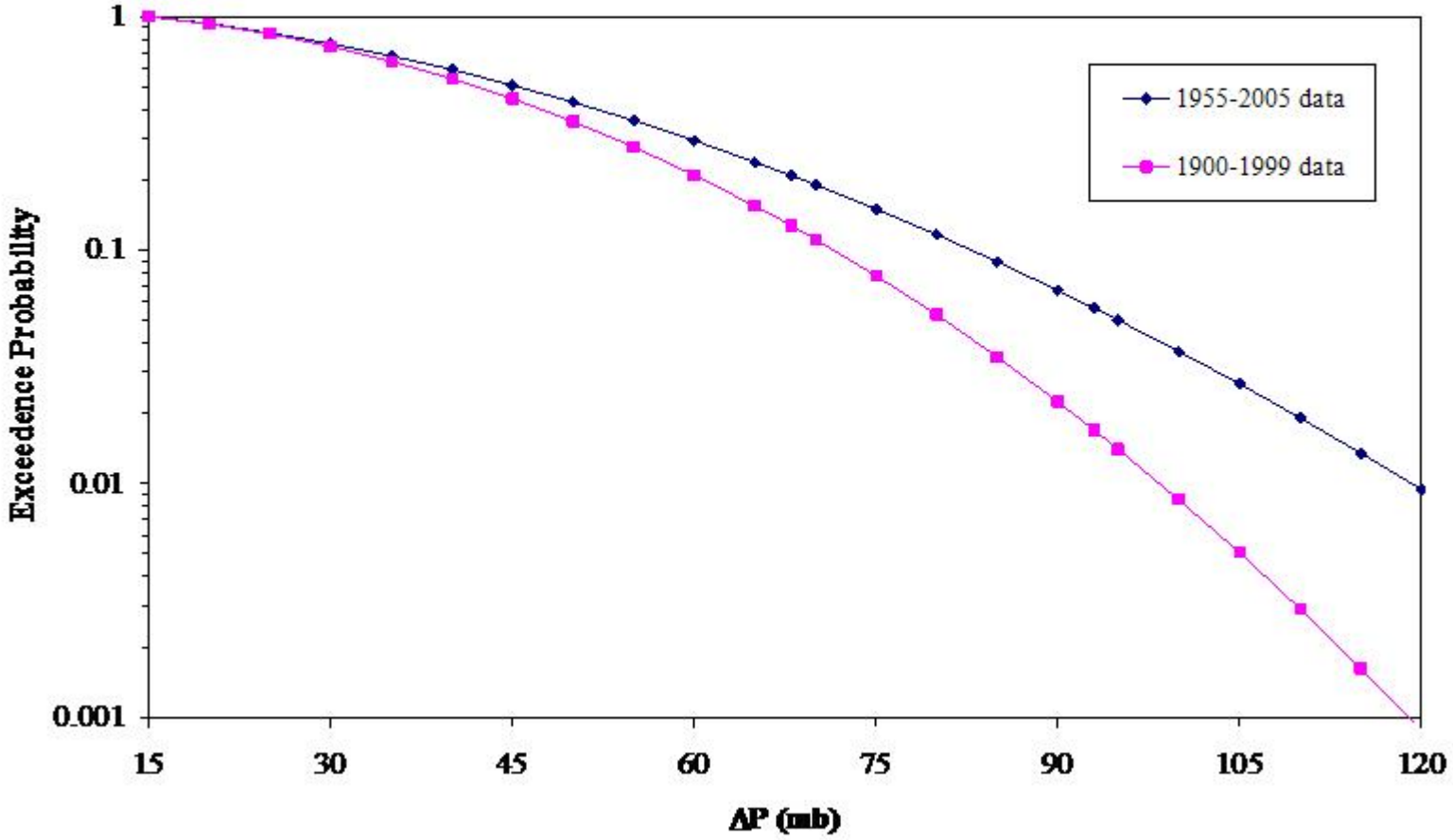
Zones A, B, and C



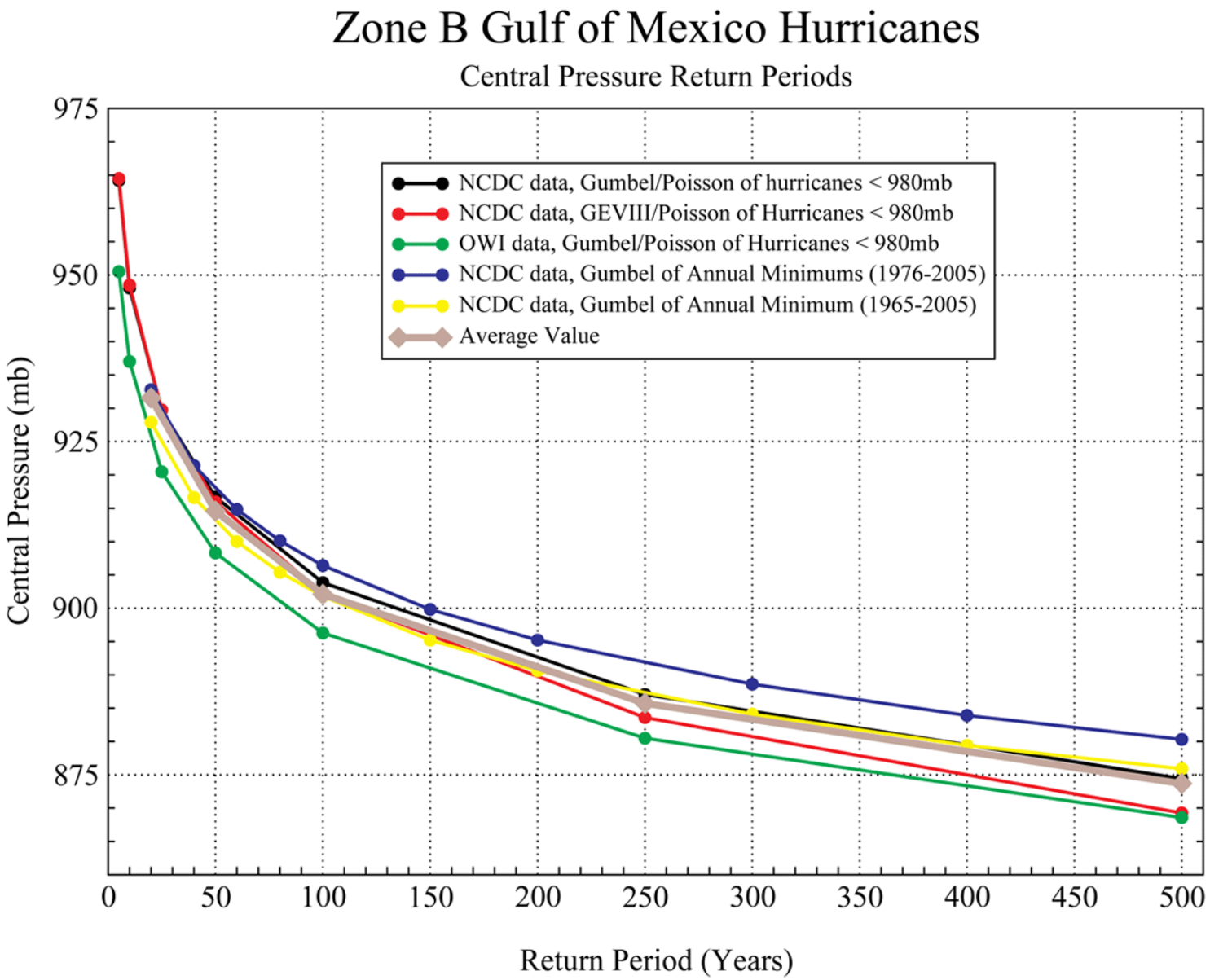

Central Gulf Coast (Zone B)
Minimum CPI (kPa)
102
100
98
96
94
92
90
88
1900
1920
1940
1960
1980
2000
Camille
Katrina


Return Periods for Original Central Pressure Indices (CPI)
Data covering the period 1900-1956
Data covering the period 1900-1975
Katrina (904 mb)
Expected CPI (mb)
Return Period (years)
935
930
925
920
915
910
905
900
895
0
100
200
300
400
500
600

Analysis of differences in expected pressure drops within hurricanes for two recent time periods

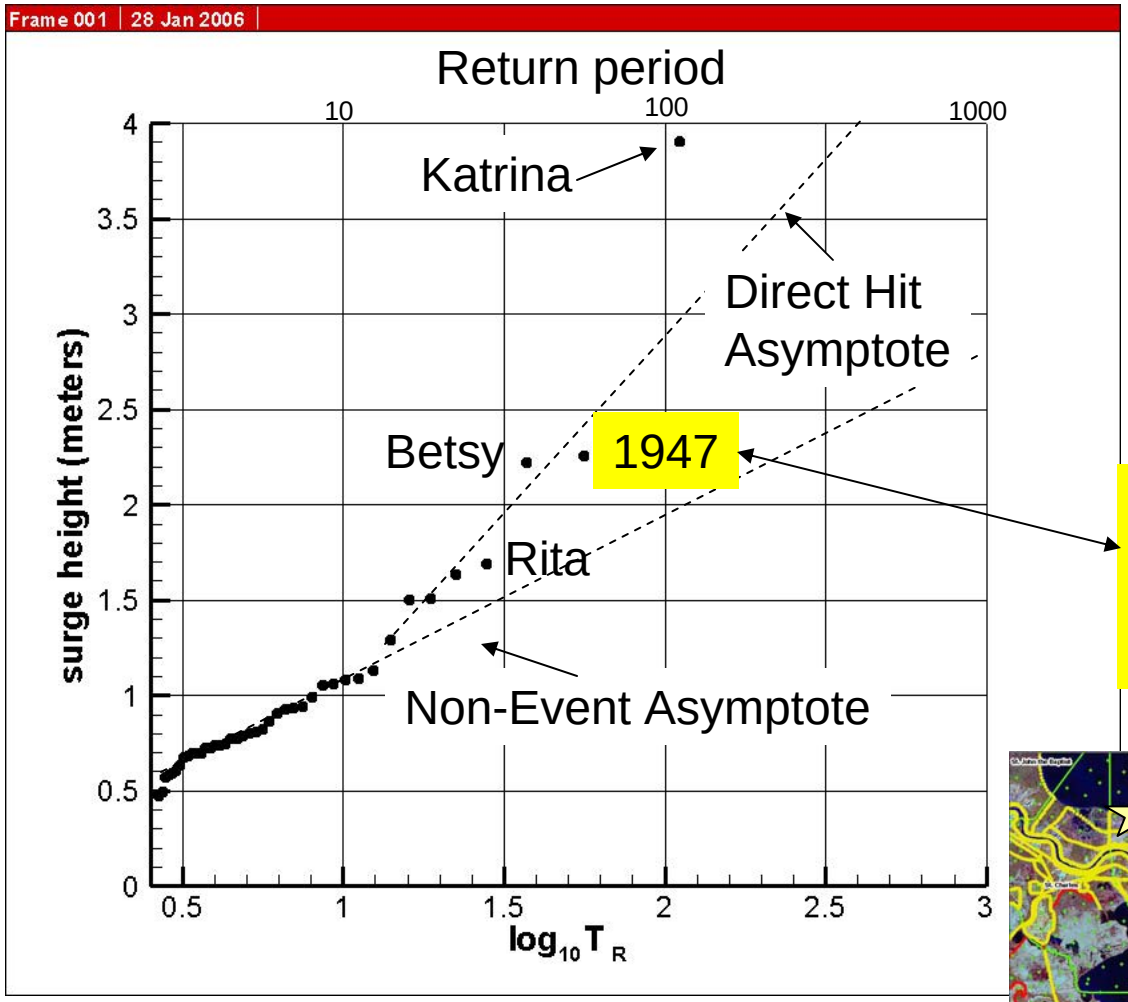


CPI Return Periods



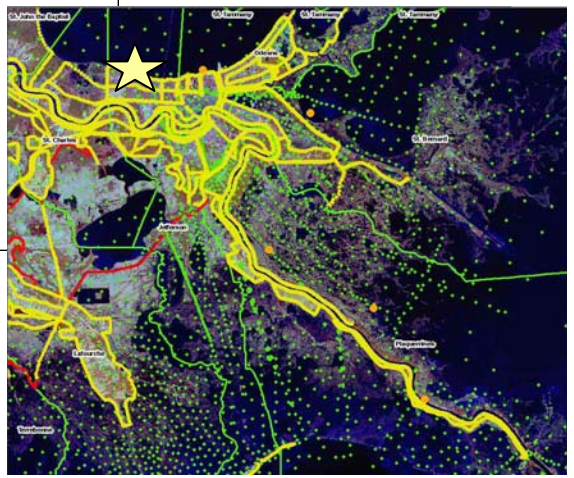
LOG Return Period Plot of ADCIRC Results

Lake Ponchartrain Point 1



Estimate based Poisson frequency And CDF

Ponchartrain "design event" may not be the same as open coast



EST analysis of water levels at point in Lake Ponchartrain
Parametric lower and upper tails
Nonparametric in interior of distribution

The Joint Probability Method (JPM)

Simulates water levels over a range of discretized parameters, typically Including

pressure deficit,
radius to maximum wind speed,
forward velocity of storm
angle of storm track relative to coast line
relative location to landfall

OMITS:
Holland B-parameter
waves
storm history

typically uses a 5-dimensional parameter set **8-dimensional?**

$$p(\eta) = p(\varepsilon_1, \varepsilon_2, ..., \varepsilon_n) J^{-1}$$

$$J^{-1} = \delta[\eta_*(\varepsilon_1, \varepsilon_2, ..., \varepsilon_n) - \eta]$$

NEED JOINT PROBALITY NOT UNIVARIATE PROBABILITIES

$$F(\eta) = \int ... \int p(\varepsilon_1, \varepsilon_2, ..., \varepsilon_n) H[\eta_*(\varepsilon_1, \varepsilon_2, ..., \varepsilon_n) - \eta] d\varepsilon_1, \varepsilon_2, ..., \varepsilon_n$$

If certain fairly straightforward conditions are met, this integral can be mapped from one area to another to provide an estimate of the probability of the surge potential of a particular hurricane **– provi**

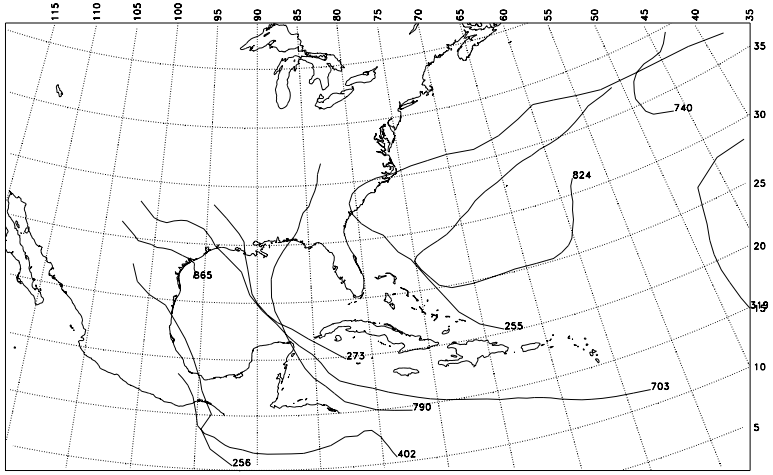
that models accurately represent surge levels and wave effects

Typically requires many more storms than EST!

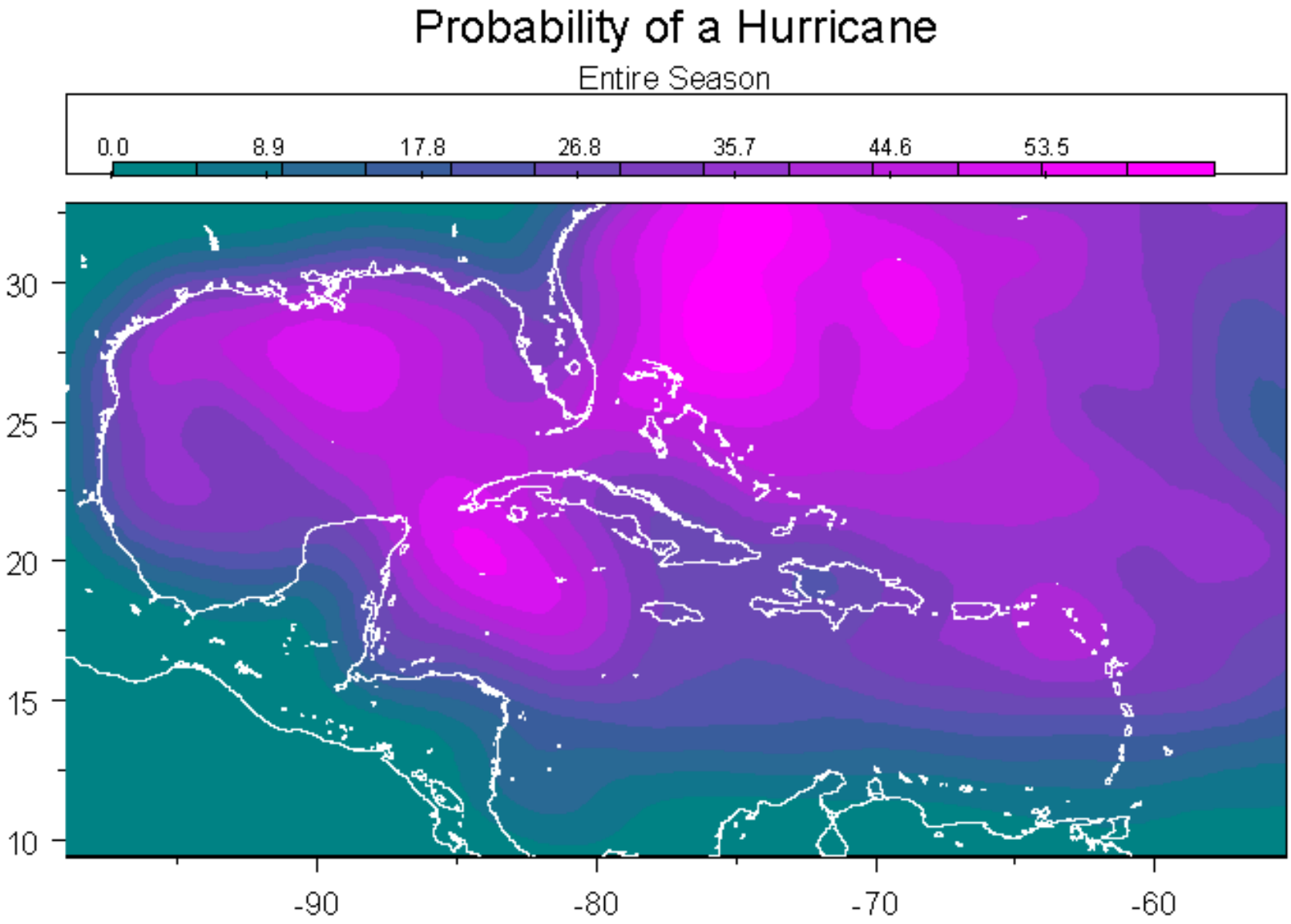
SYNTHETIC STORM MODEL

Vickery & Twisdale

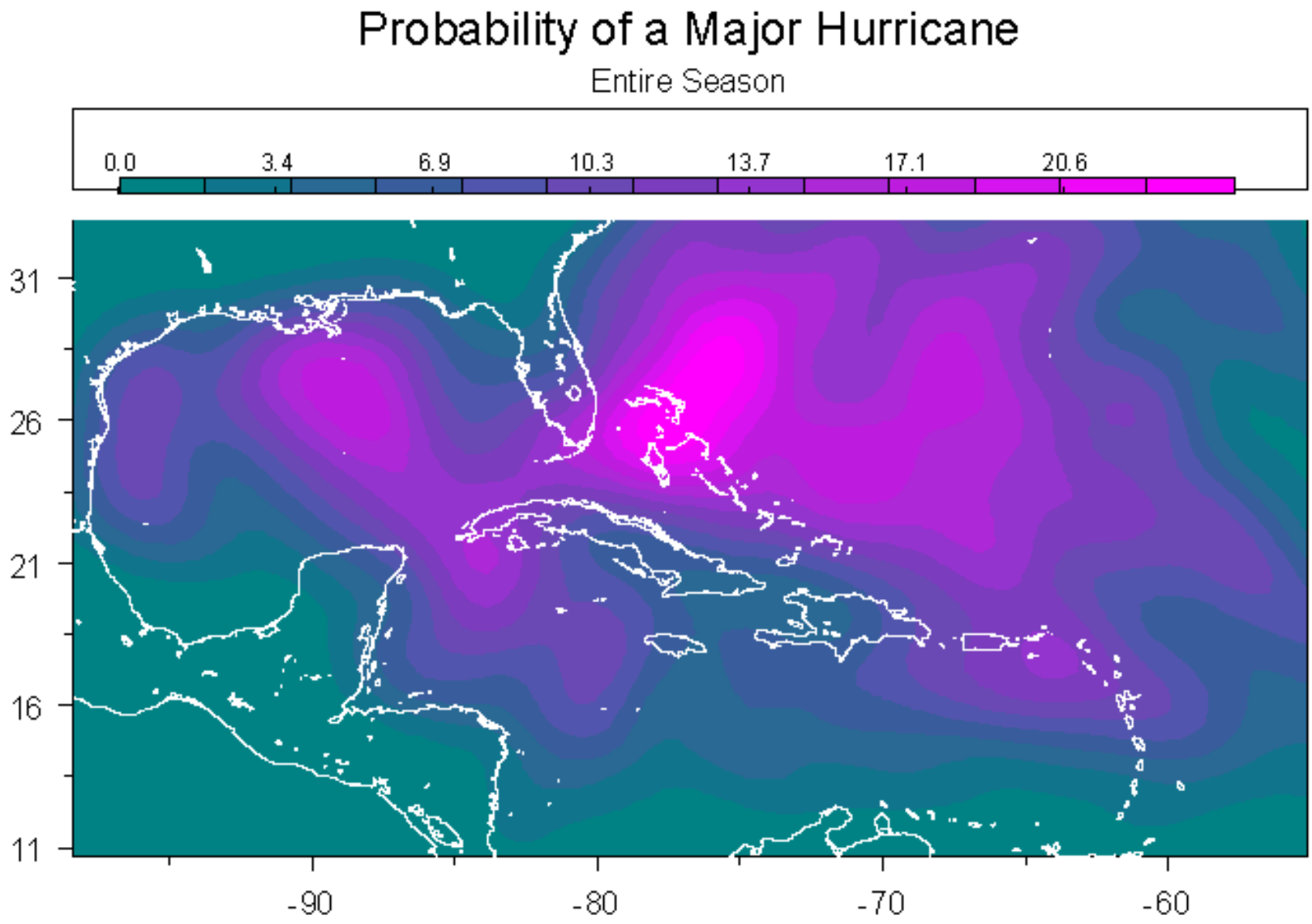
- Storms initiated in Atlantic, Caribbean and Gulf of Mexico
- Models storm curvature and changes in intensity with time
- Central pressure modeled as a function of sea surface temperature
- Approach allows for modeling of multiple land falls
- Uses filling models from Vickery (2005)
- R_{max} - Δp and R_{max} – latitude models which are an improvement of Vickery and Twisdale (1995)



Monte Carlo method – good for life cycle analysis

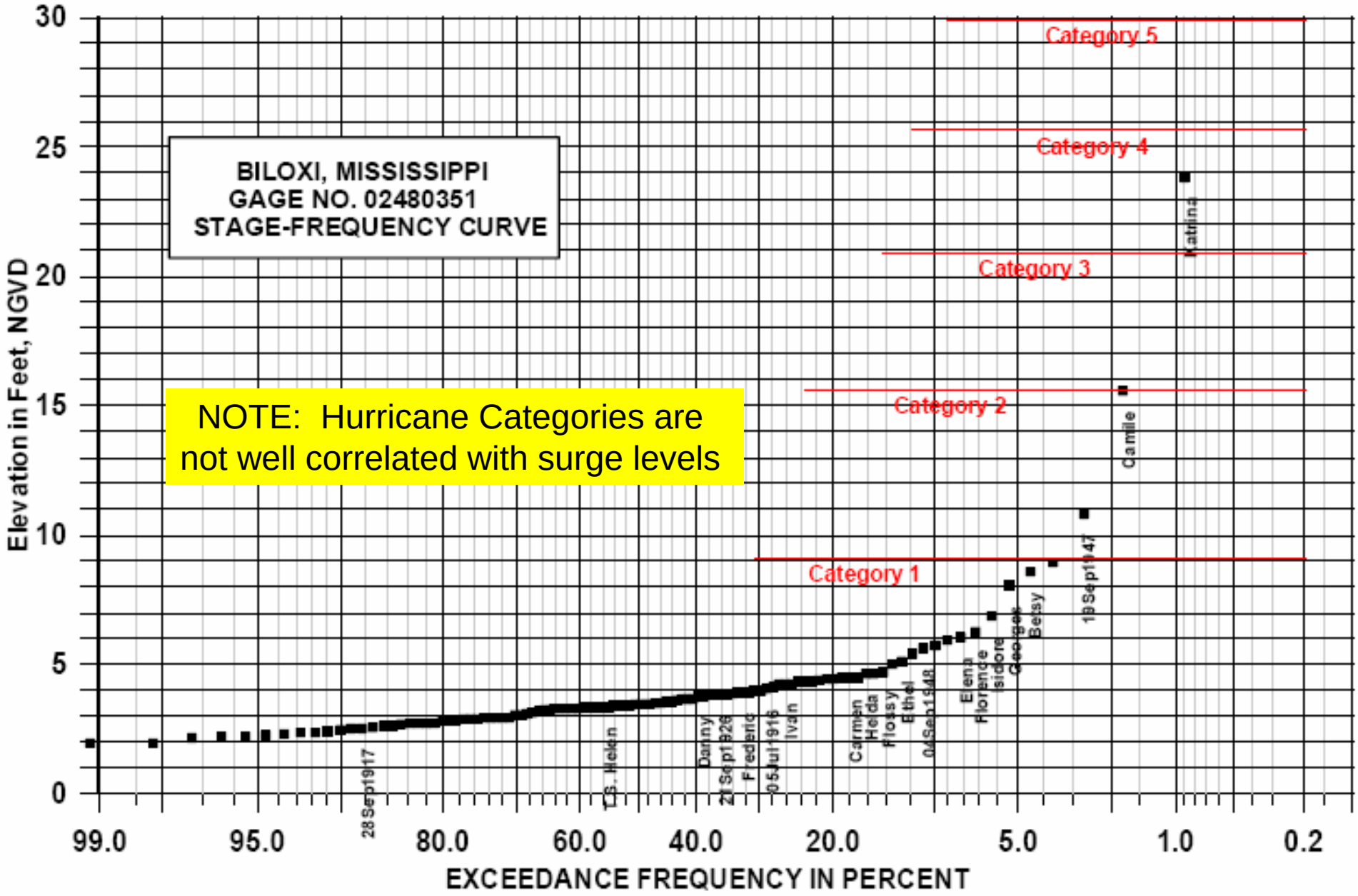


Hurricane probabilities are not spatially homogeneous.



Major hurricane probabilities are not spatially homogeneous.

NOAA Historical Data Analysis with Hypothetical Category Impact Superimposed

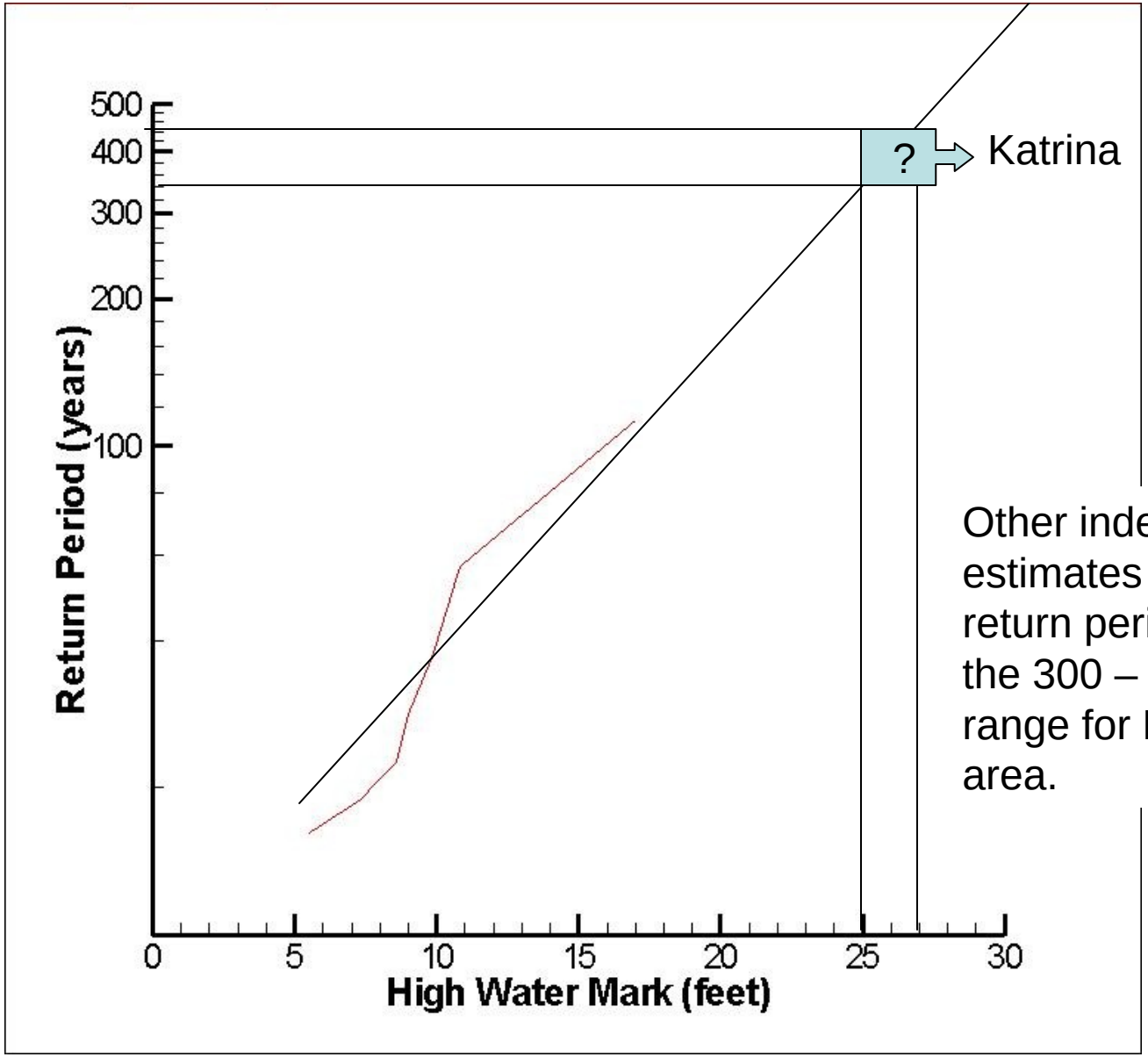


"Gage" is also HWM and Historical Information

PERIOD OF RECORD, 1882-2005

HISTORICAL CHARACTERIZATION
Over 100 Years of High Water Marks
Biloxi, Mississippi

Hurricane	High Water Mark	S-S #
1893	9.0	3
1915	9.9	4
1947	10.8	2
1965 (Betsy)	8.6	3
1969 (Camille)	17.0	5
1985 (Elena)	7.3	3
1998 (Georges)	5.5	1
2005 (Katrina)	26.0	3



Other independent estimates of Katrina's return period lie in the 300 – 500 year range for New Orleans area.

Estimate of Return Period for Katrina based on 112 years of High water marks Biloxi, MS – (pre-Katrina)


QUESTIONS??