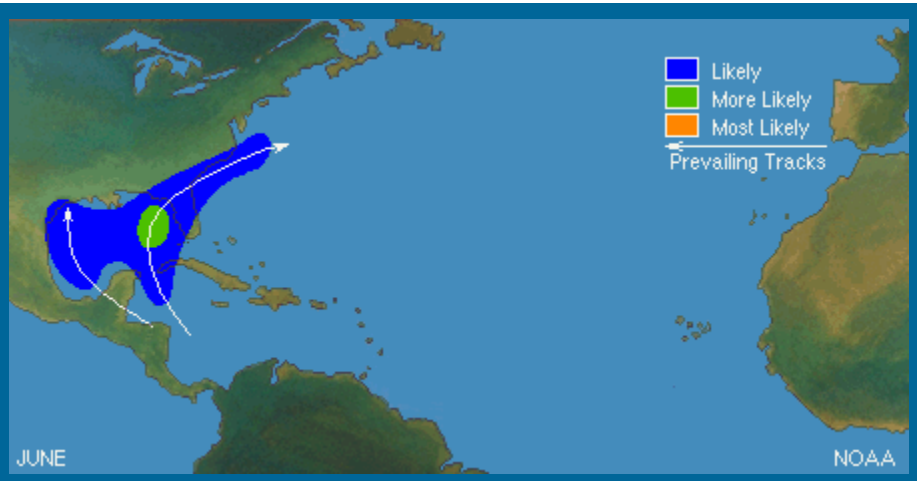
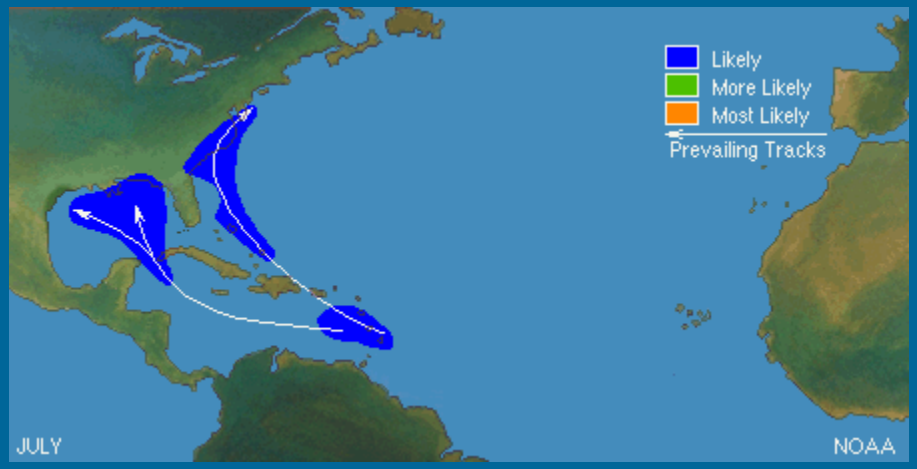

Hurricane Season is Here
Is This Year the East Coast's Year?

Hurricanes

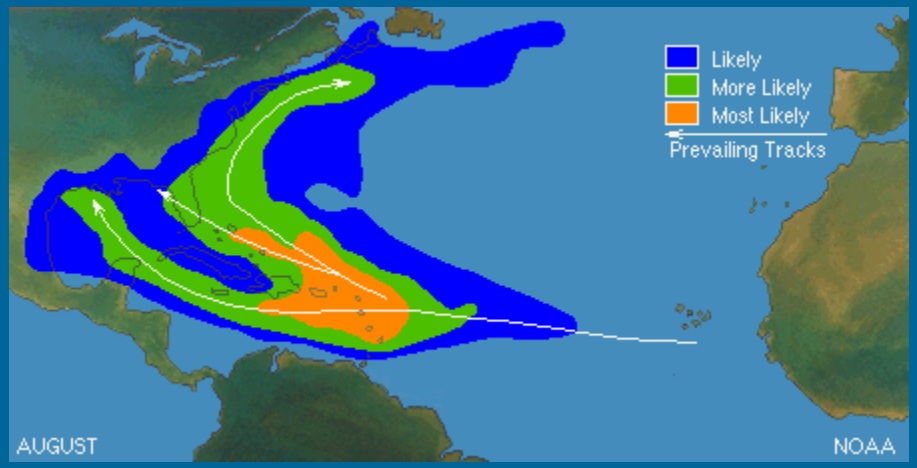
- Derive their energy from warm ocean waters (>80F) which provide heat directly to the air and indirectly to the storm through the release of “latent heat” when water vapor, which evaporates from the warm ocean, condenses in the clouds.
- Hurricanes are giant heat engines – the average storm generates heat energy equivalent to all the electric energy produced in the US in an entire year *(Chris Landsea NOAA HRL).*



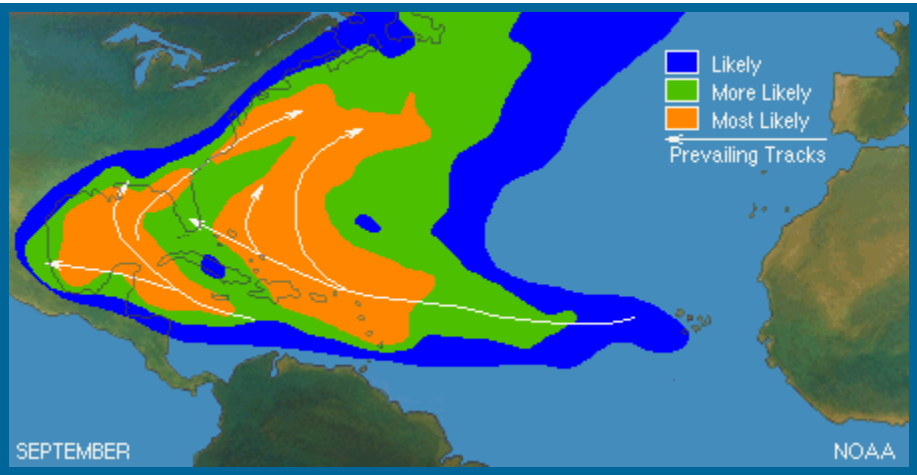
June – early weak systems Usually from Caribbean or Gulf of Mexico (where oceans are first to become warm enough)



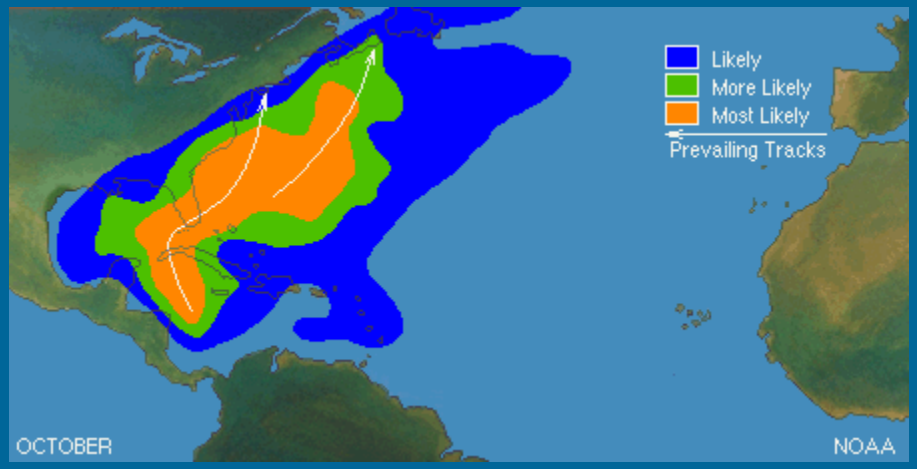
July – Caribbean west and east and Gulf of Mexico. Also weak tropical storms off the southeast US coast



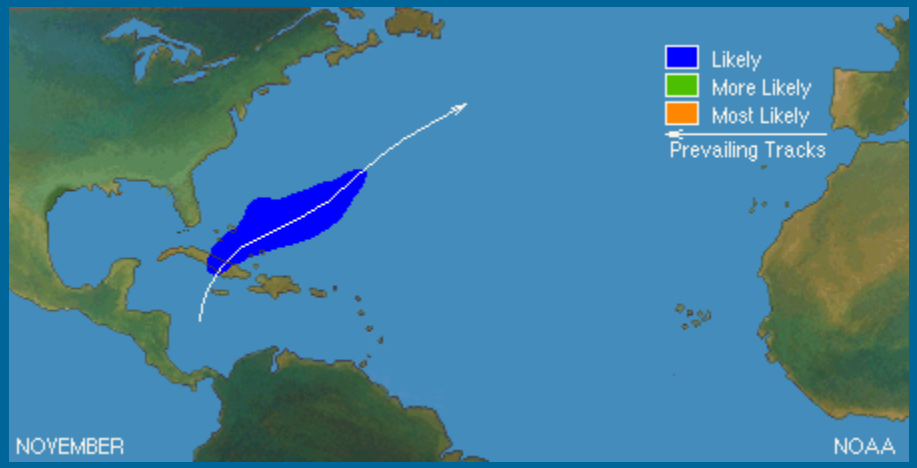
August - Vulnerable to first Cape Verde systems, prime area though is eastern Caribbean to the Bahamas



September– activity peaks early (10th) Caribbean, Gulf of Mexico and Western Atlantic activity all peak



October – Cape Verde season over. Most October storms from the Caribbean or "home grown' from near the mainland.

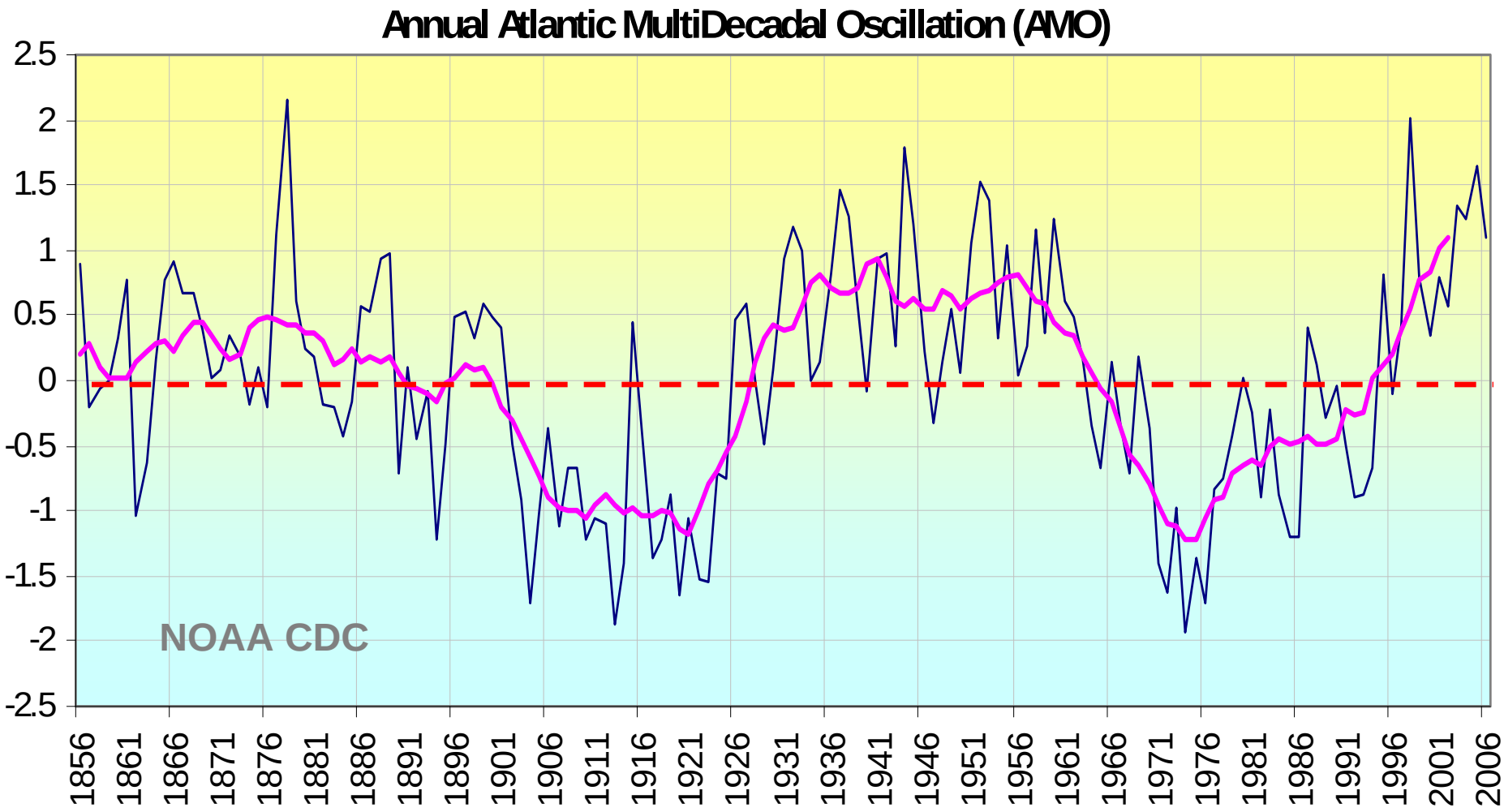


November – activity becomes rare, storms usually weak. Mainly the Islands of the western Atlantic

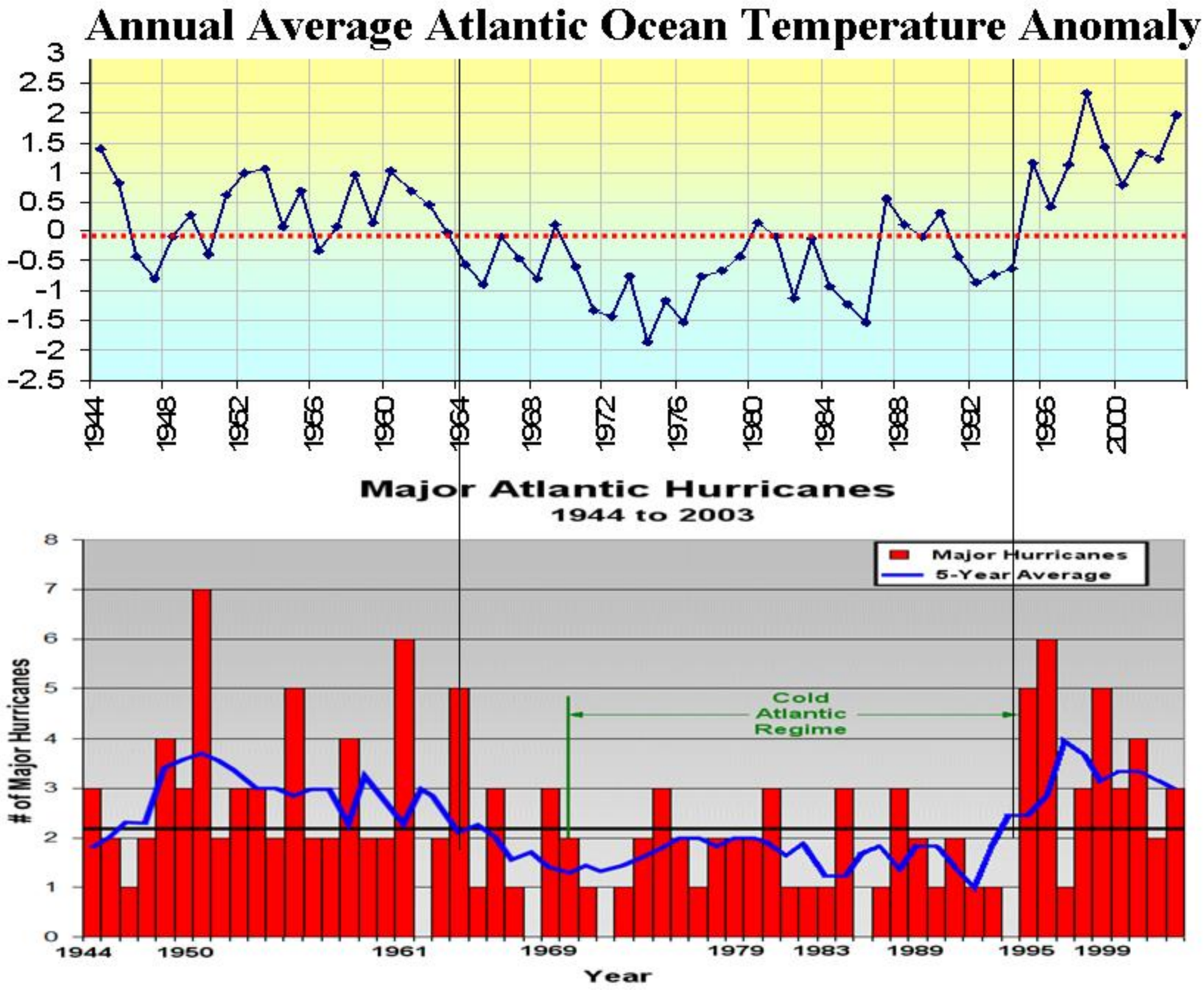
May 10
June 1
June 20
July 10
Aug 1
Aug 20
Sept 10
Oct 1
Oct 20
Nov 10
Dec 1
Dec 20
110
100
90
80
70
60
50
40
30
20
10
0
Number of Storms per 100 Years
Hurricanes and Tropical Storms
Hurricanes
NOAA

Upswing In Hurricane Activity

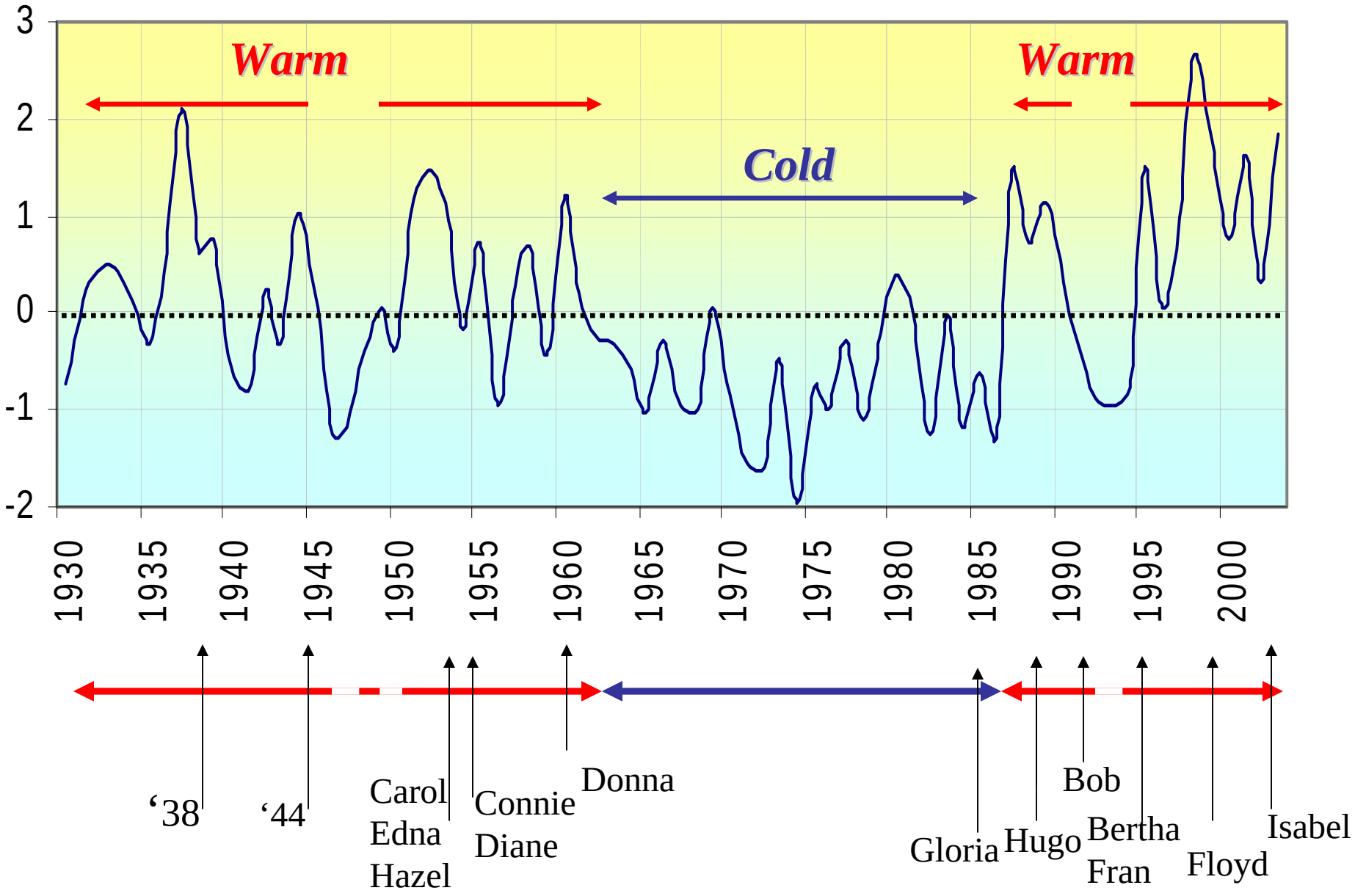
- Since 1995, the Atlantic has become twice as active on average as the prior 25 years, similar to the period from 1930s to 1960s
- This is due to a shift to the ‘warm” mode of the multi-decadal scale oscillation in the Atlantic Ocean
- Most of the storms making landfall during the past 10 years have impacted the Mid-Atlantic region, Florida and the Gulf of Mexico
- However, though not yet realized, history tells us that the risk has also increased for more populated areas to the north (Long Island and New England)



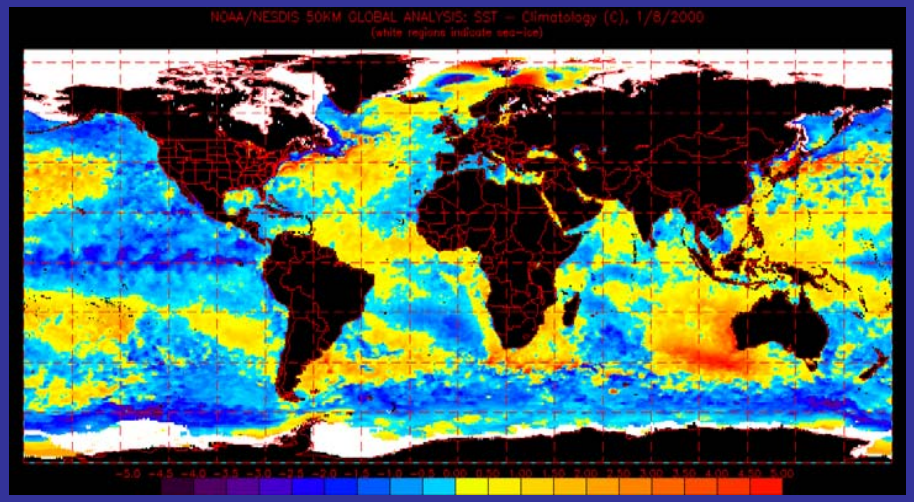
Mean ocean temperature anomalies in the Atlantic from 0 to 70N

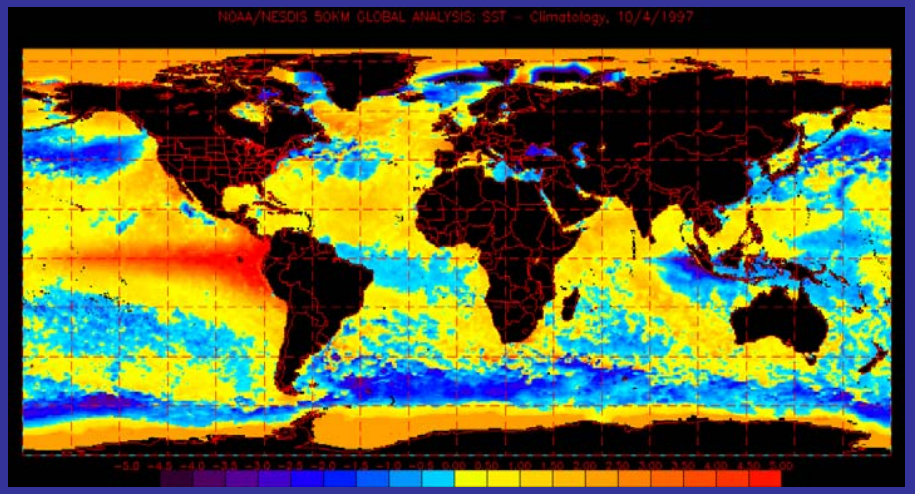

Annual Average Atlantic Ocean Temperature Anomaly
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1944
1948
1952
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
Major Atlantic Hurricanes
1944 to 2003
Major Hurricanes
5-Year Average
Cold Atlantic Regime
# of Major Hurricanes
0
1
2
3
4
5
6
7
8
1944
1950
1961
1969
1979
1983
1989
1995
1999
Year

East Coast Hurricanes and Atlantic Temperatures



The Pacific Ocean may affect the activity in the Atlantic and where the storms go during the hurricane season

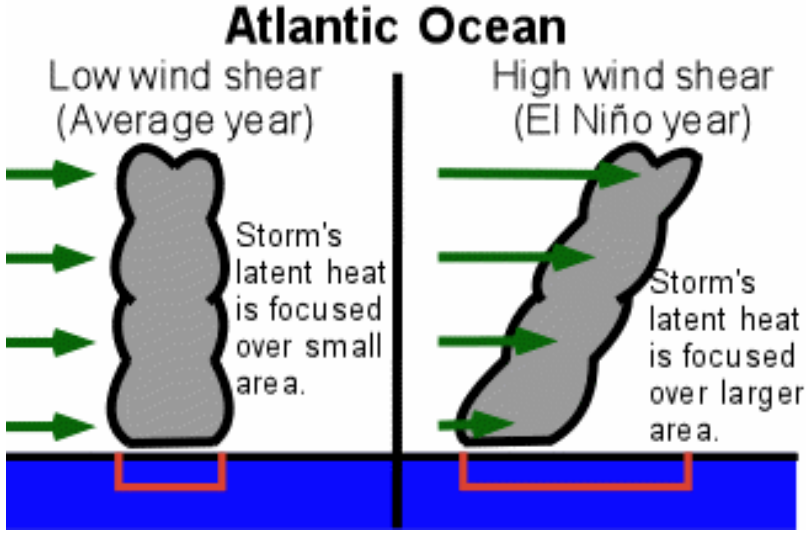




LA NINA

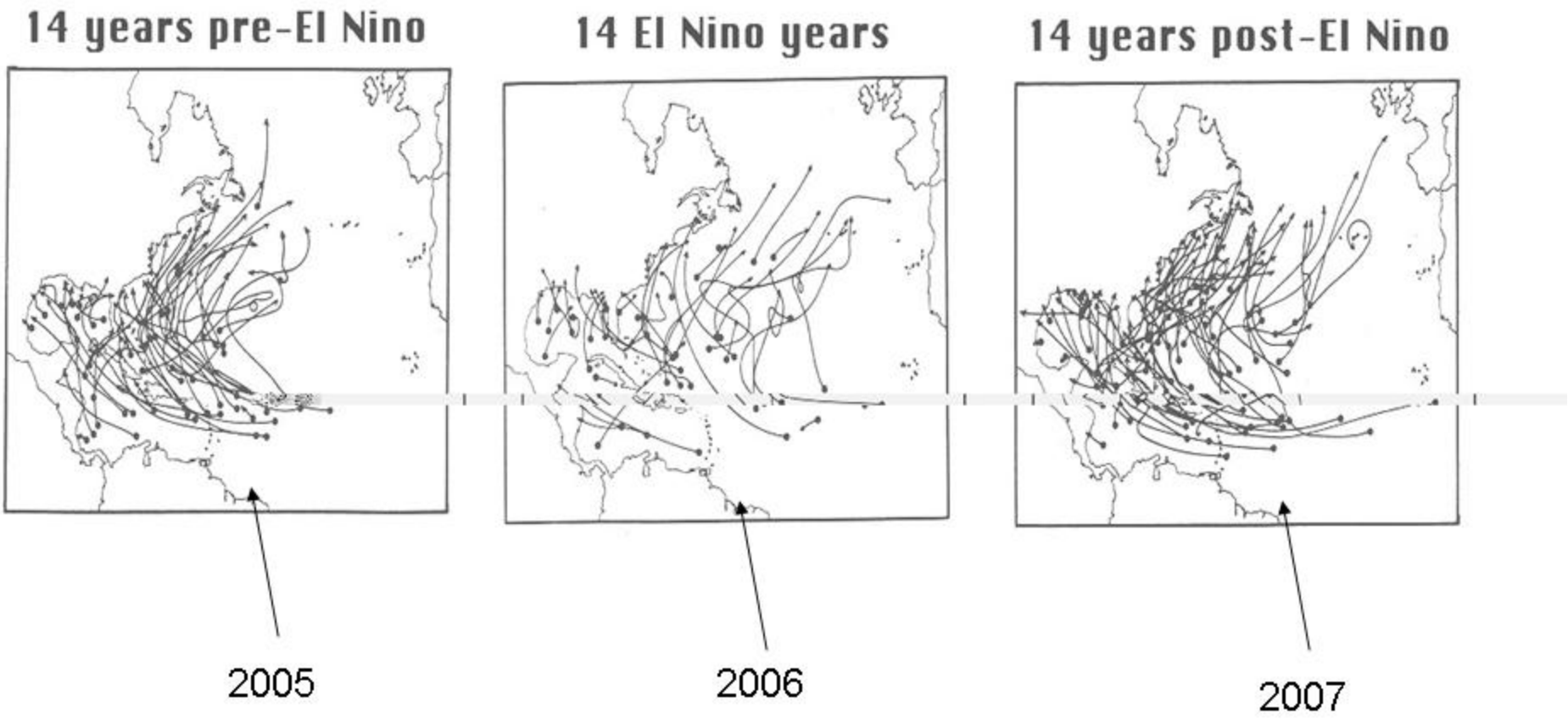
EL NINO

El Ninos Also Suppress Activity

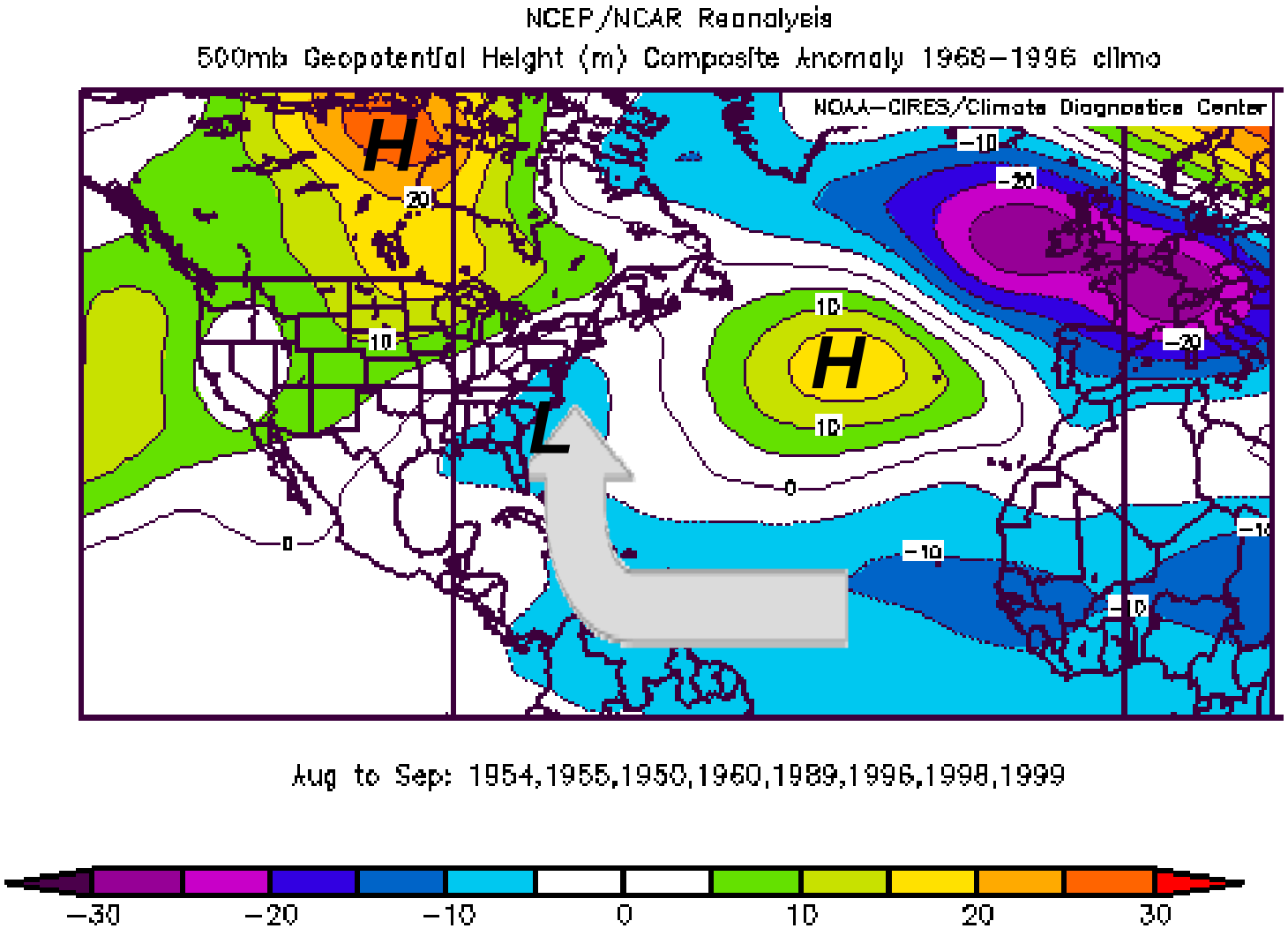


In El Ninos, more eastern Pacific hurricanes produce outflow that Increases upper level westerlies across the Atlantic. The result is that Atlantic systems are torn apart or at least retarded in their development as they move west. 2006 was a good example of this.

Hurricane Track the Summer Before, During and After an El Nino



La Nina Upper Steering Level

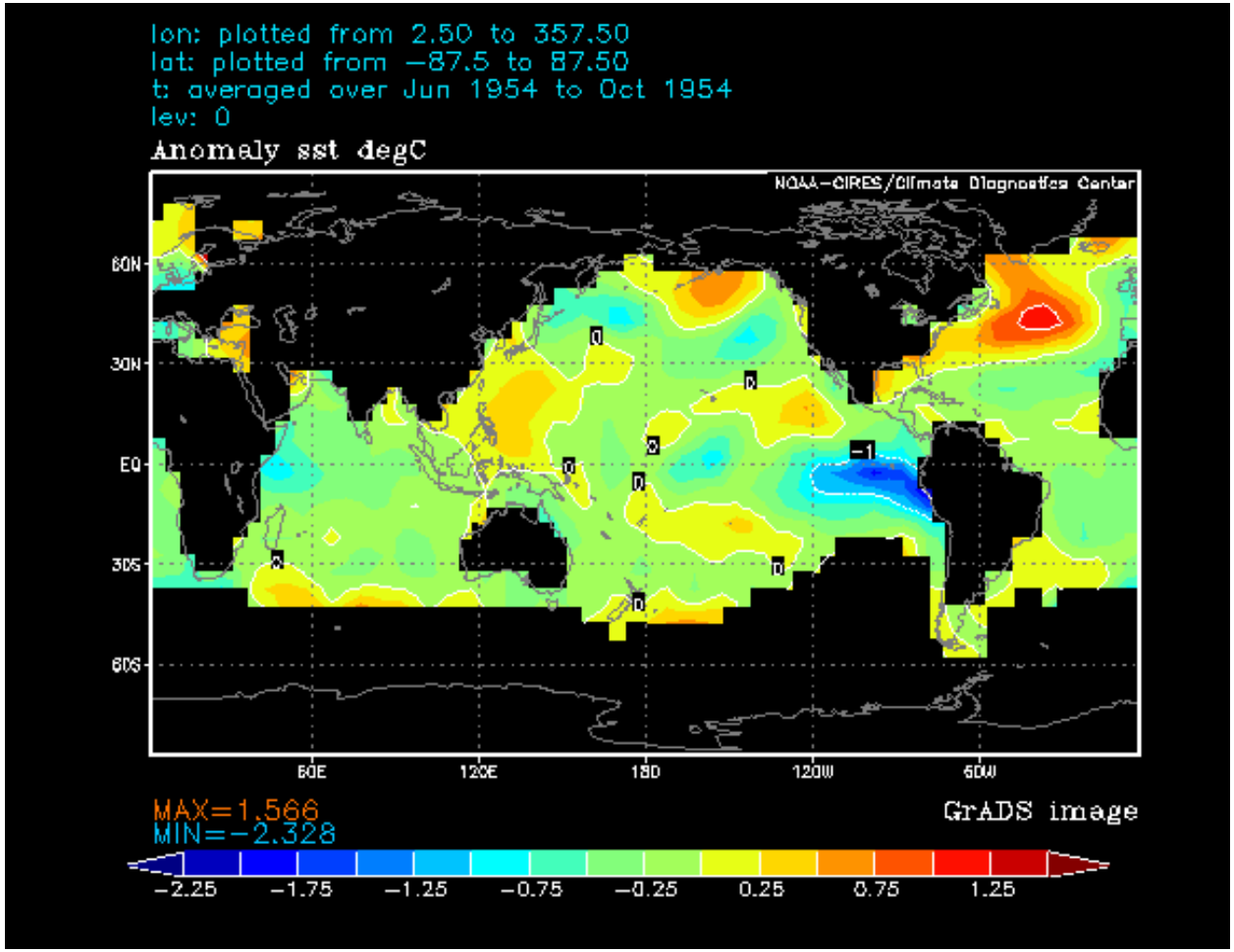


Aug to Sep: 1954,1955,1950,1960,1989,1996,1998,1999

Worst Scenario for East

- **Atlantic in its warm mode (more and stronger storms)**
- **La Nina in the Pacific (more likely to recurve up the east coast)**

The Classic Year 1954



La Nina Years Occurring with Warm Atlantic Summers

1938 Hurricane of '38 (CAT 5) New York and New England

1950 Hurricane Easy (CAT 3) Florida, Hurricane King (CAT 3) Florida

1954 Hurricane Carol (CAT 3) New York and New England,
Hurricane Edna (CAT 3) New England, Hurricane Hazel (CAT 4) Mid-Atlantic and northeast

1955 Hurricane Connie (CAT 3) NC, VA, NY, New England Flooding,
Hurricane Diane (Cat 1) NC, New England Flooding

1960 Hurricane Donna (CAT 4) FL (CAT 4), NY (CAT 3), New England

1989 Hurricane Hugo (CAT 4) SC

1996 Hurricane Bertha (CAT 2) NC, Hurricane Fran (CAT 3) NC

1998 Hurricane Bonnie (CAT 2) NC

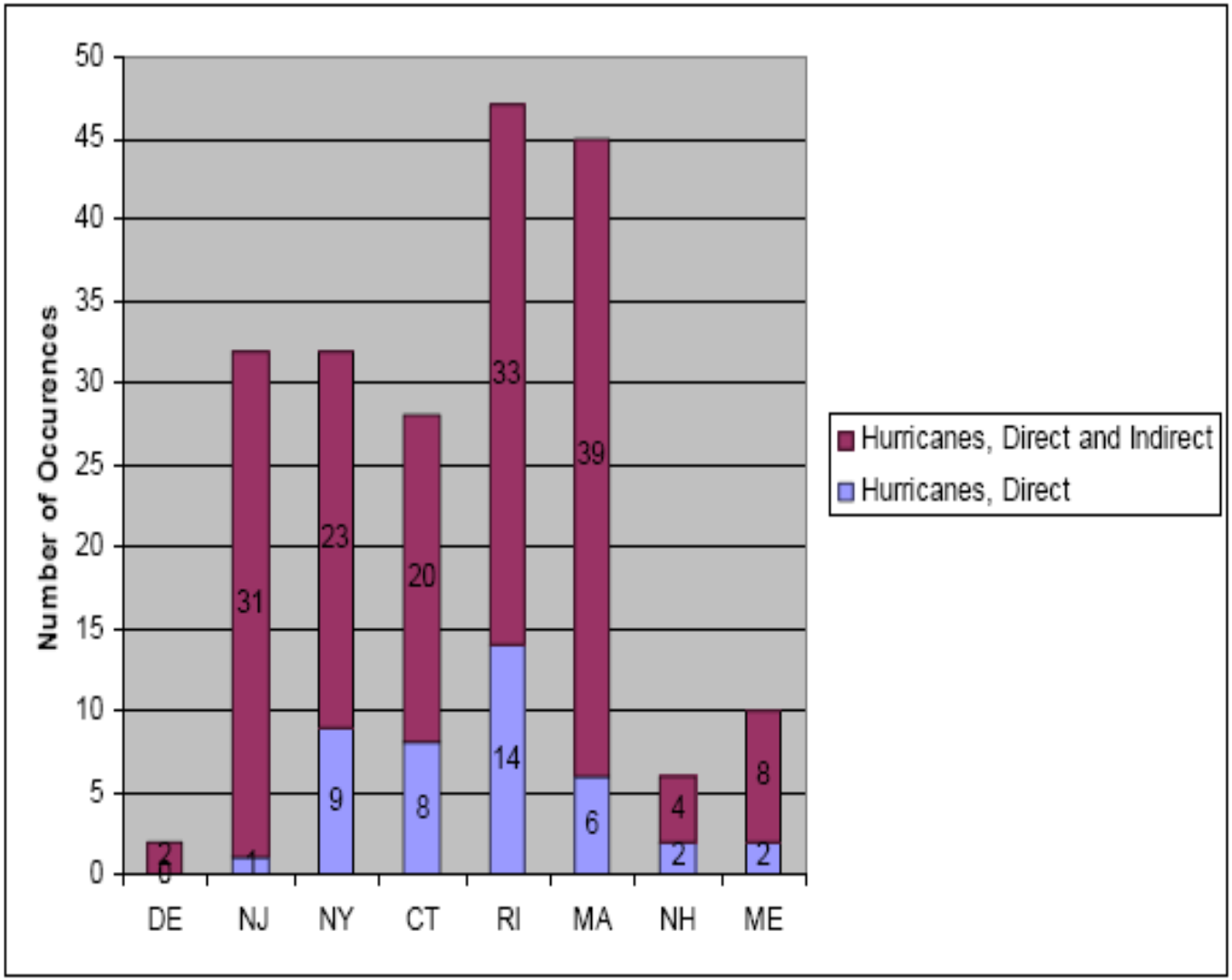
1999 Hurricane Floyd (CAT 2/3) NC

15 landfalling storms in the 9 years!!!!! 11 major hurricanes

Two Areas of Greatest Concern

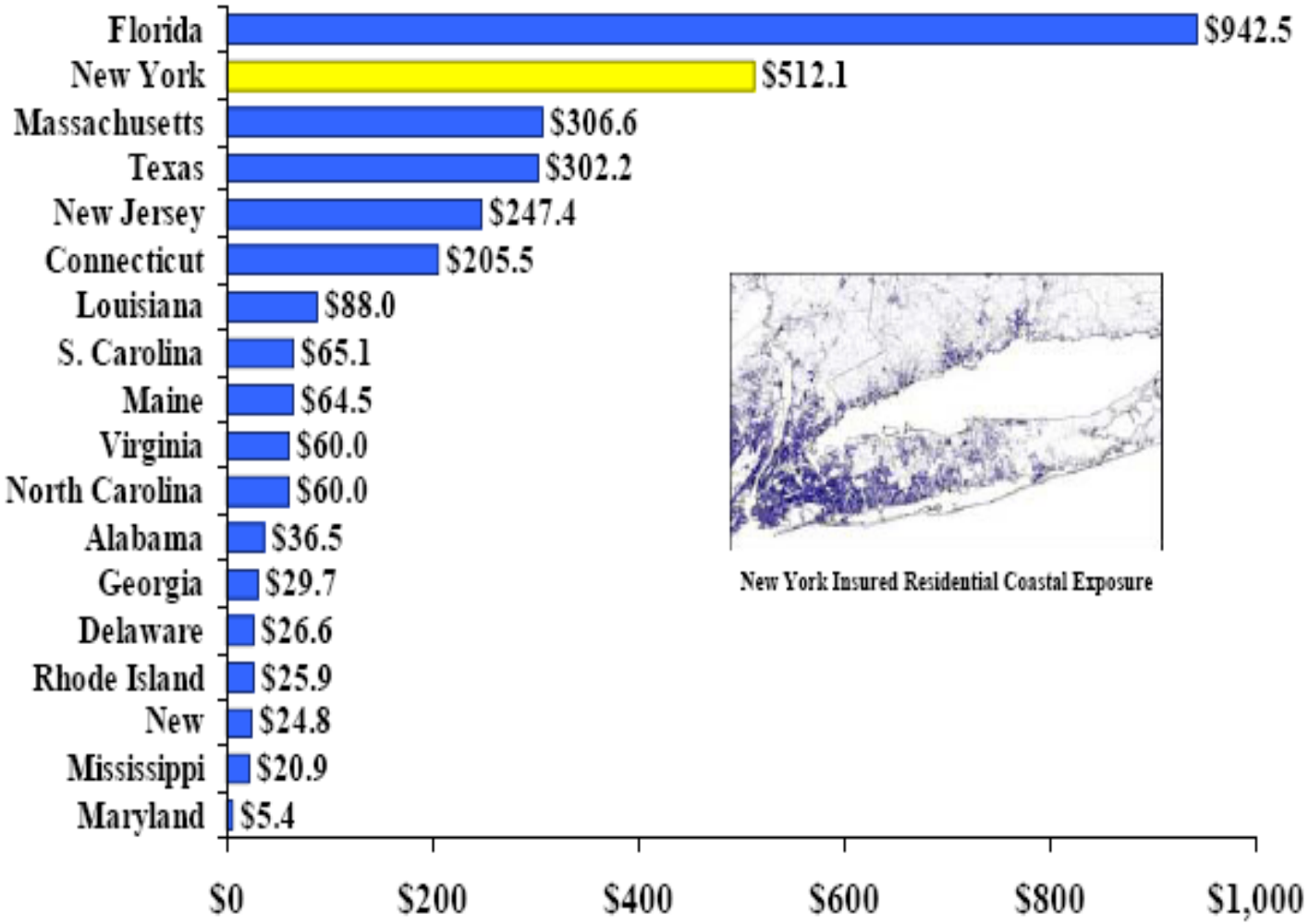
- New York Metropolitan Area and Long Island
- Southeastern New England

Number of Hurricanes Directly and Indirectly Affecting the Northeast United States Since 1900



Source: New Hampshire Office of Emergency Management

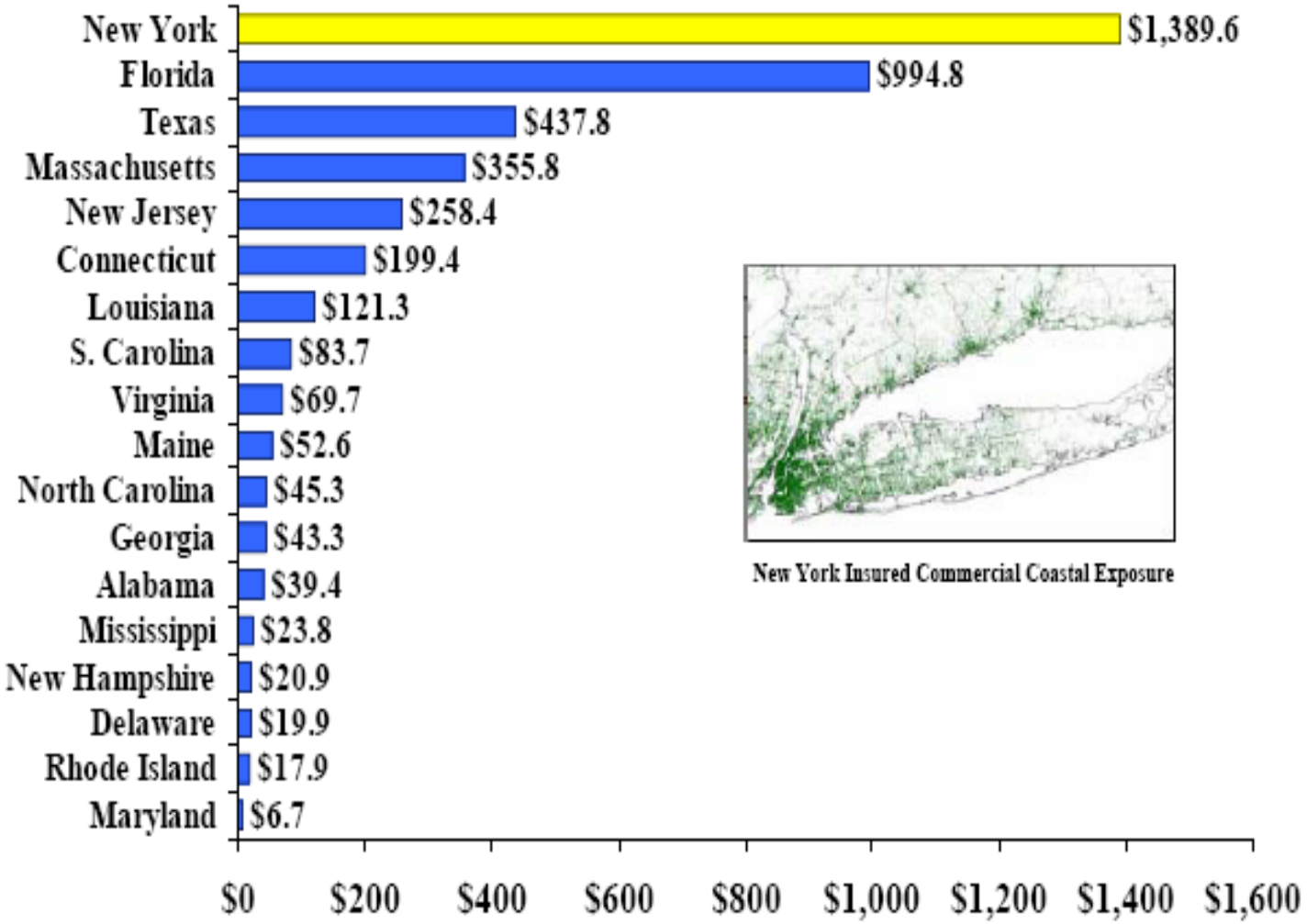
Value of Insured Residential Coastal Exposure (2004, $ Billions)



New York Insured Residential Coastal Exposure

Source: AIR

Value of Insured Commercial Coastal Exposure (2004, $ Billions)



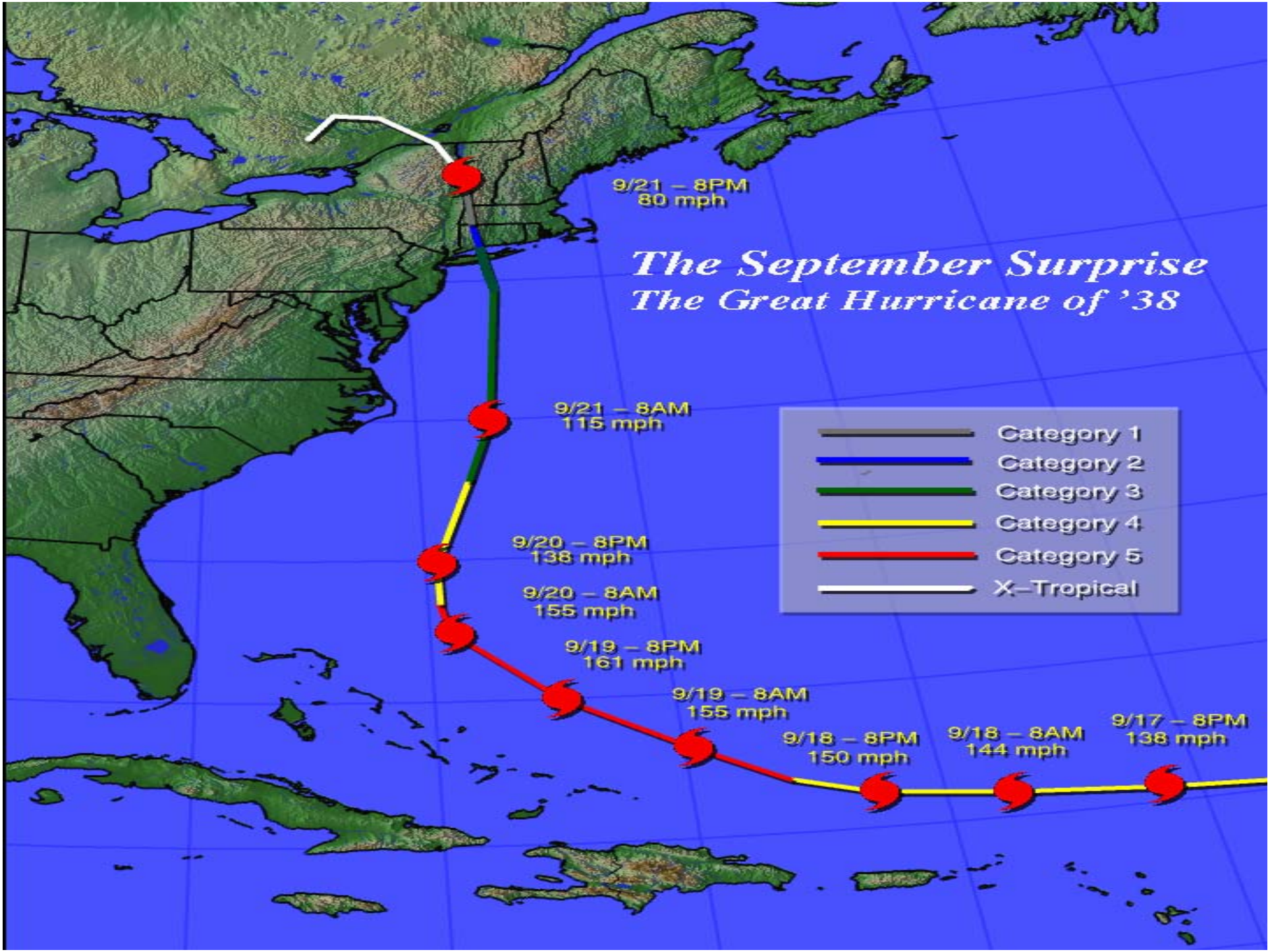
New York Insured Commercial Coastal Exposure

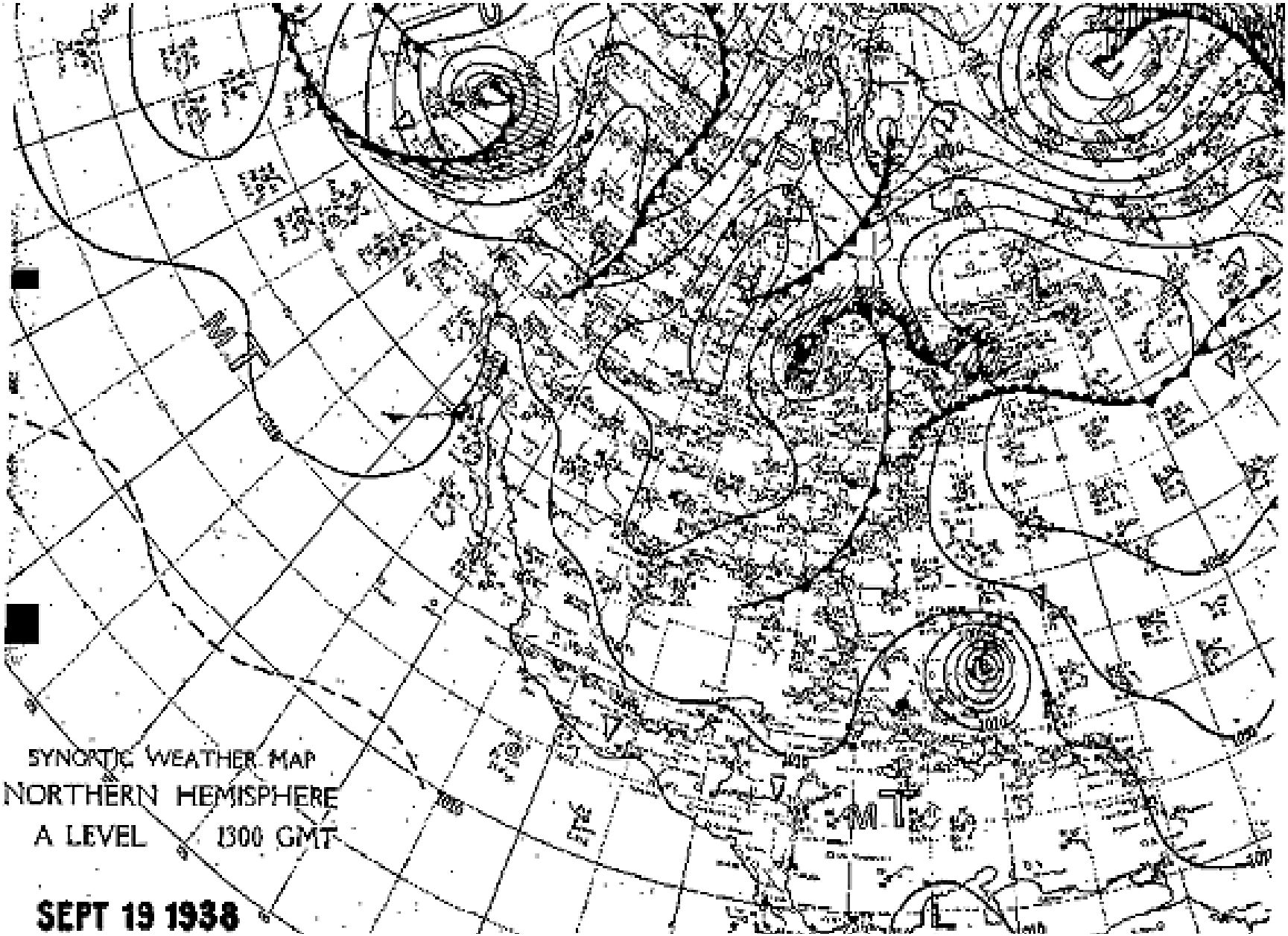
Source: AIR

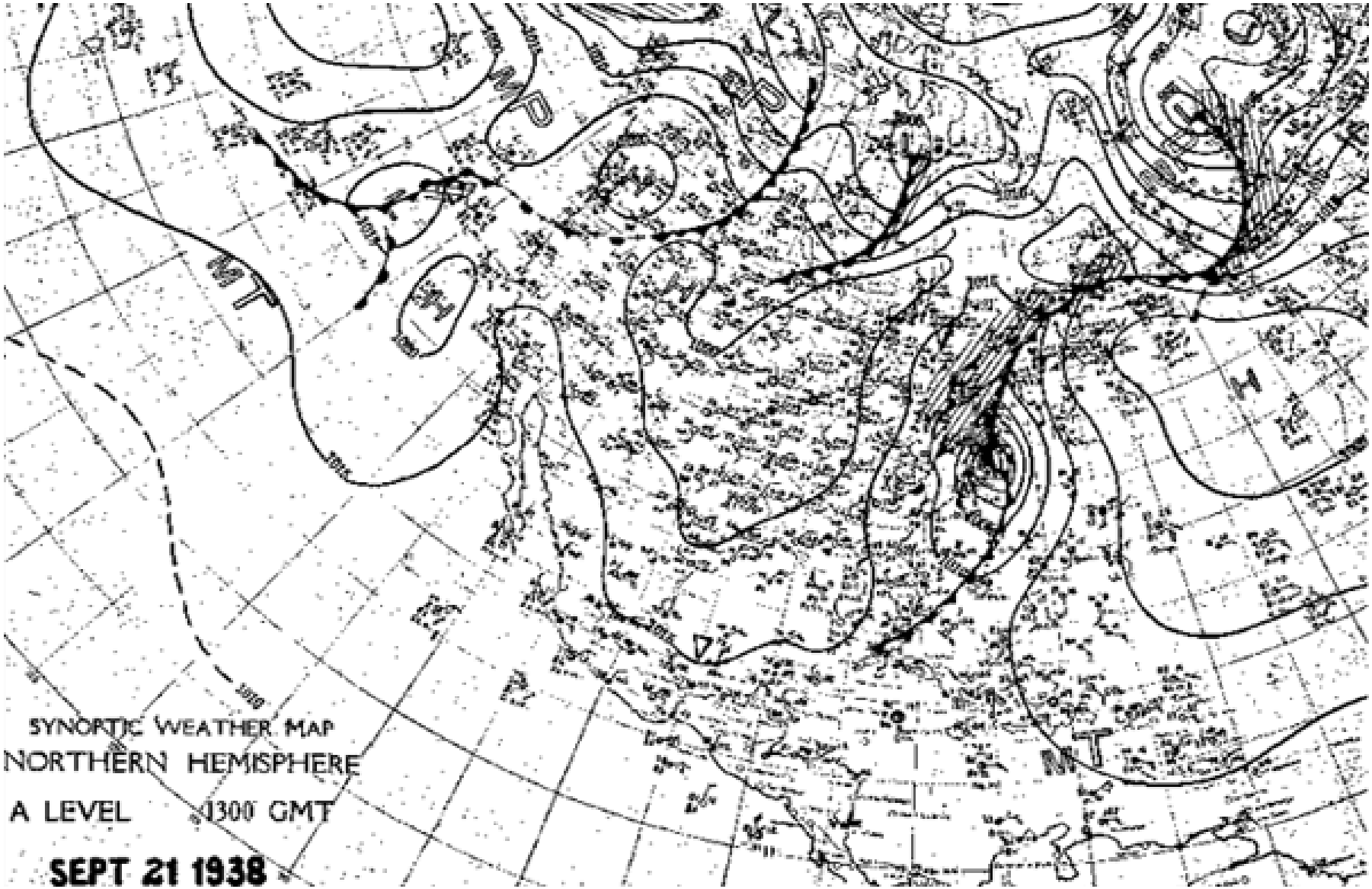
EPIC Hurricanes to affect NYC/Long Island (strong CAT 3 or greater storms at landfall)

- 1938
- 1893
- 1821
- 1815
- 1635

Return Frequency of about 80 years
Scheffner and Butler (1996)


The September Surprise
The Great Hurricane of '38
9/21 – 8PM
80 mph
9/21 – 8AM
115 mph
9/20 – 8PM
138 mph
9/20 – 8AM
155 mph
9/19 – 8PM
161 mph
9/19 – 8AM
155 mph
9/18 – 8PM
150 mph
9/18 – 8AM
144 mph
9/17 – 8PM
138 mph
Category 1
Category 2
Category 3
Category 4
Category 5
X–Tropical


SYNOPTIC WEATHER MAP
NORTHERN HEMISPHERE
A LEVEL 1300 GMT
SEPT 19 1938


SYNOPTIC WEATHER MAP
NORTHERN HEMISPHERE
A LEVEL 1300 GMT
SEPT 21 1938

Ware, MA, 1938. Flooding in the aftermath of a nameless Hurricane. The force of the water tore out the stone bridge in the center of the photo. Photo courtesy of NOAA.

If (When) It Happens Again

- Christopher Landsea (HRD) and Roger Pielke (NCAR) estimated if a storm like the Hurricane of '38 were to happen today, it would be the sixth costliest of all-time.
- In 1998 dollars, their study estimated it would produce $18 billion or more in damages today across NY and New England

Far Worse if Closer to New York City

- AIR Worldwide's Karen Clark at the National Catastrophe Insurance Program Summit in November, 2005 if such a storm made landfall just to the east of New York City **would result in approximately $50 billion of insured losses with total economic losses exceeding $100 billion**…. *"since the total value of exposed properties in coastal areas of New York State alone has increased to over $1.9 trillion."*
- Approximately one-quarter of the $100 billion in total economic losses would be attributable to storm surge. The contour of New York's coastline and relatively shallow depth of its coastal waters make it extremely vulnerable to storm surge.

New York and Hurricanes

- At the time of the 1938 storm, Long Island was a rural home for oyster fishermen, potato farmers and wealthy industrialists.
- More than 20 million people live in the greater metropolitan region today. Many live on coastal land, reclaimed swamp and barrier islands.
- Much of Lower Manhattan is built on landfill. Places like Rockaway, Coney Island and Manhattan Beach "are stretches of land that nature has created to protect the mainland from hurricanes," Mike Lee (NYCOEM) says. "In our civilization this is also the most desirable land to develop and build on. ... so we now have to deal with the threat."

Storm Surge Threat

- A storm surge prediction program used by forecasters called *SLOSH* (Sea, Lake, and Overland Surge from Hurricanes) has predicted that in a category 4 hurricane, John F. Kennedy International Airport would be under 20 feet of water and sea water would pour through the Holland and Brooklyn-Battery tunnels and into the city's subways throughout lower Manhattan.

Storm Surge Threat

- The highest storm surges (Category 4) would occur in the following regions:
  - Amityville Harbor - 29 feet
  - Atlantic Beach & Long Beach areas - 24 to 28 feet
  - South Oyster Bay, Middle Bay, & East Bay areas - 24 to 28 feet
- Excellent site with graphics that show storm surge flooding http://www2.sunysuffolk.edu/mandias/38hurricane/storm_surge_maps.html

Army Corp Models Even Worse

- In the event of a direct hit by a category-3+ hurricane, surge maps show that the Holland and Battery Tunnels will be *completely* filled with sea water, with many subway and railroad tunnels severely flooded as well. The runways of LaGuardia and JFK airports will get flooded by 18.1 and 31.2 feet of water, respectively.

New York Direct Hit

- If a storm like the Long Island Express makes a direct hit on the city, everything below Broome Street will be inundated, some parts under as much as 20 and 30 feet of water. Chelsea and Greenwich Village would be completely flooded, with the Hudson spilling over all the way to 7th Avenue. Likewise, the East River and East Village become one, with ocean water surging all the way to 1st Avenue.

- If you haven't evacuated before the storm, forget it. During the storm, Manhattan's east- and west-side highways vanish. Tunnels and bridges become unusable.

Flooding widespread south west and east in Manhattan

Public Perceptions

- Before the ’38 storm, New York had not felt the power of a major hurricane since 1893. Not since 1815 had a storm of this intensity struck New England. Most people have never even heard of the word hurricane or were totally unaware that they could affect non-tropical climes

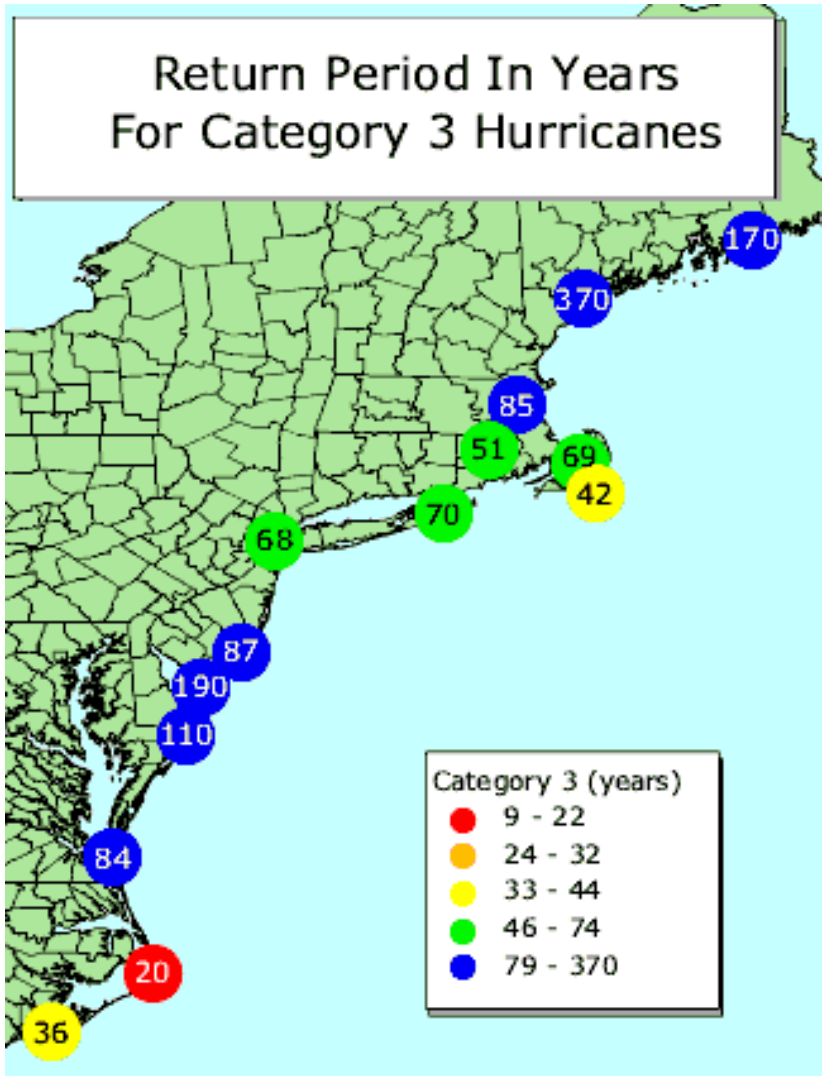
Public Perceptions

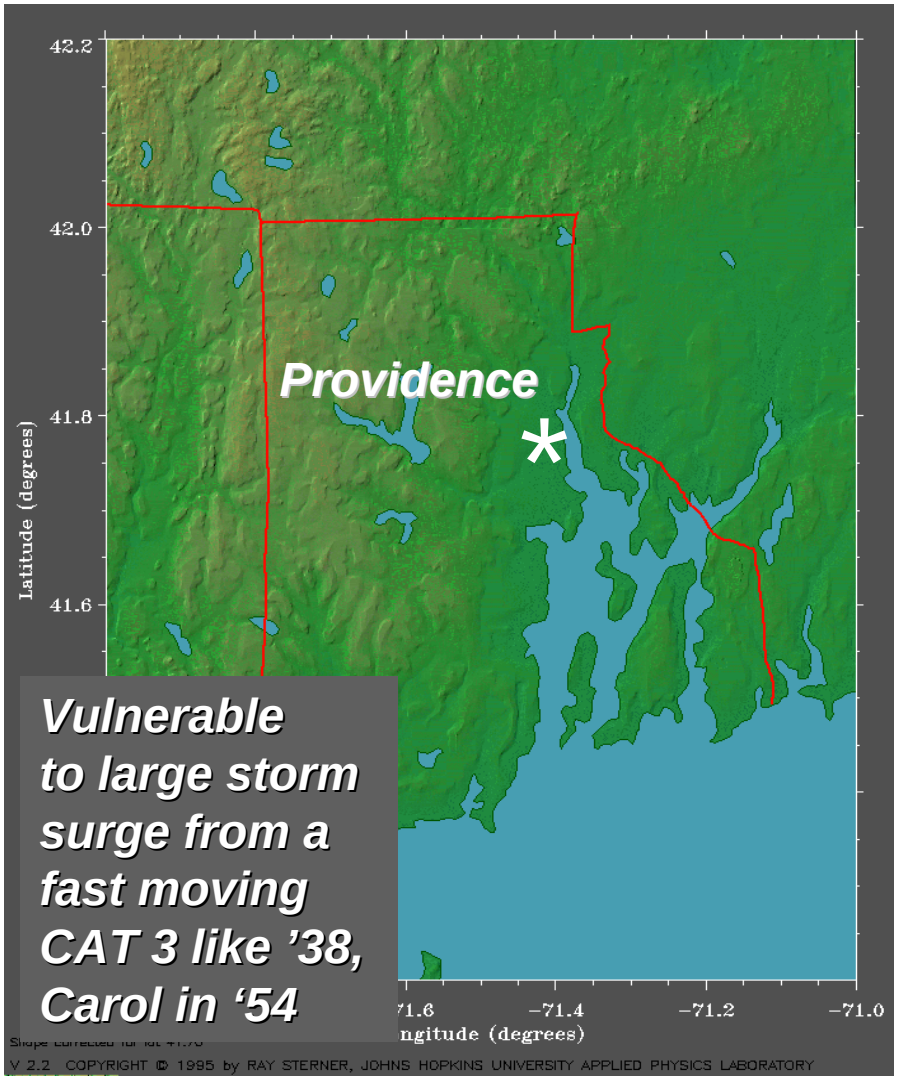
- Today, approximately 78.5% of current New York State coastal residents have never experienced a major hurricane (Hughes)
- Though people are now aware what hurricanes can do (images of Katrina burned in their memory), there is a misguided sense that the region is not vulnerable to same kind of storm as the Gulf or Florida and would experience only minor inconveniences (downed trees, and temporary power outages)

Public Perceptions

- In reality even here in the northeast, strong hurricanes threaten to bring a wall of water two stories high, winds on a large-scale the equivalent of an F2 or even F3 tornado, and a normal season's rainfall in a day.

Threat to Southeast New England





Last Cat 3 in PVD 1954, 52 years ago

Threat to Southeast New England

- According to Maurice Spaulding an ocean engineering professor at URI in the Providence Journal (Dec, 2005)
  - Providence's Fox Point Hurricane Barrier was built to withstand a 20 1/2-foot surge. The Hurricane of 1938 sent a 15.7-foot wall of water up the Bay, and the surge from Carol in 1954 was only a foot lower.
  - A storm surge of 14.7 feet would put Providence's Field's Point under water. A surge of 24 feet would put the entire Providence waterfront underwater

Rhode Island

- In Rhode Island there are vulnerable neighborhoods such as Matunuck, in South Kingstown, Misquamicut, in Westerly, and Common Fence Point, in Portsmouth, where residents would be urged to leave. They are scarcely above sea level.

- State officials blocked redevelopment in some areas that were destroyed by the Hurricane of 1938 -- Napatree Point, in Westerly, and barrier beaches where Misquamicut and East Matunuck State beaches now stand.

- But during the last 50 years, nearly 12,000 houses have been built near the ocean along Rhode Island's south shore. Another 500 acres along Narragansett Bay have been filled in and the Bay's shoreline is jammed with houses and marinas

September 22, 1938, Island Park, RI. Island Park was destroyed by a breaker with a reported height of 30 to 40 feet. Photo courtesy of NOAA.

The front of City Hall and the Biltmore Hotel, downtown Providence. Photo by Adler Art Associates.

September 22, 1938, Bristol, RI. Damage to a building in Bristol. This storm traveled 600 miles in 12 hours, surprising Southern New England and causing widespread destruction. Photo courtesy of NOAA.

September 22, 1938, Shawomet Beach, RI. WPA workers and rescue squads search for bodies and survivors at Shawomet Beach, south of Providence. Photo courtesy of NOAA.

Hurricane Carol 1954

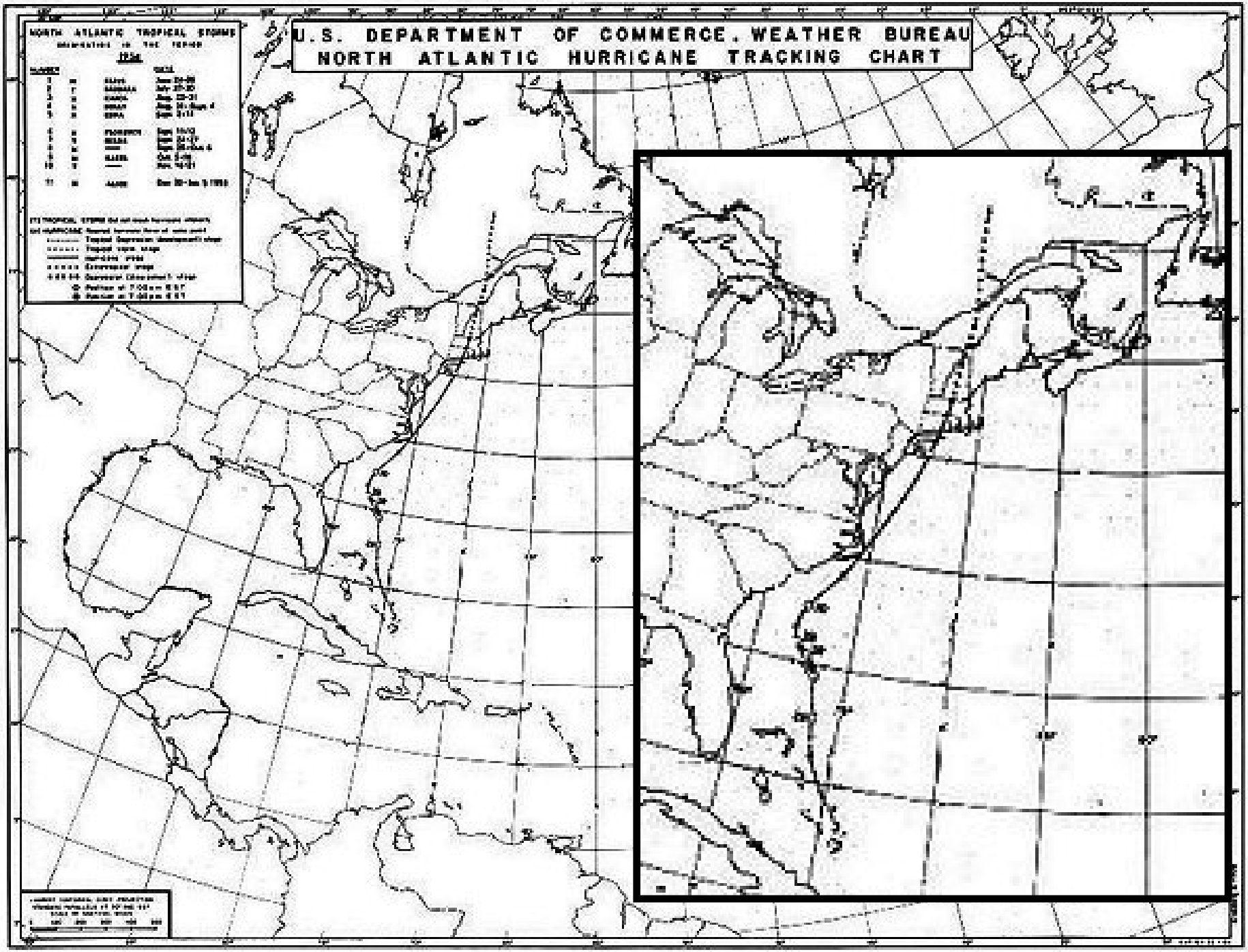
- Southeastern Massachusetts was hit severely by Carol. Carol was more damaging to southeastern Massachusetts than the 1938 hurricane.

- Around New Bedford and Buzzards Bay, the scene was one of devastation. Tides in Buzzards Bay reached their highest known levels since records were kept. The massive storm surge swept away cottages and destroyed the many small boatyards along both ends of Buzzards Bay.

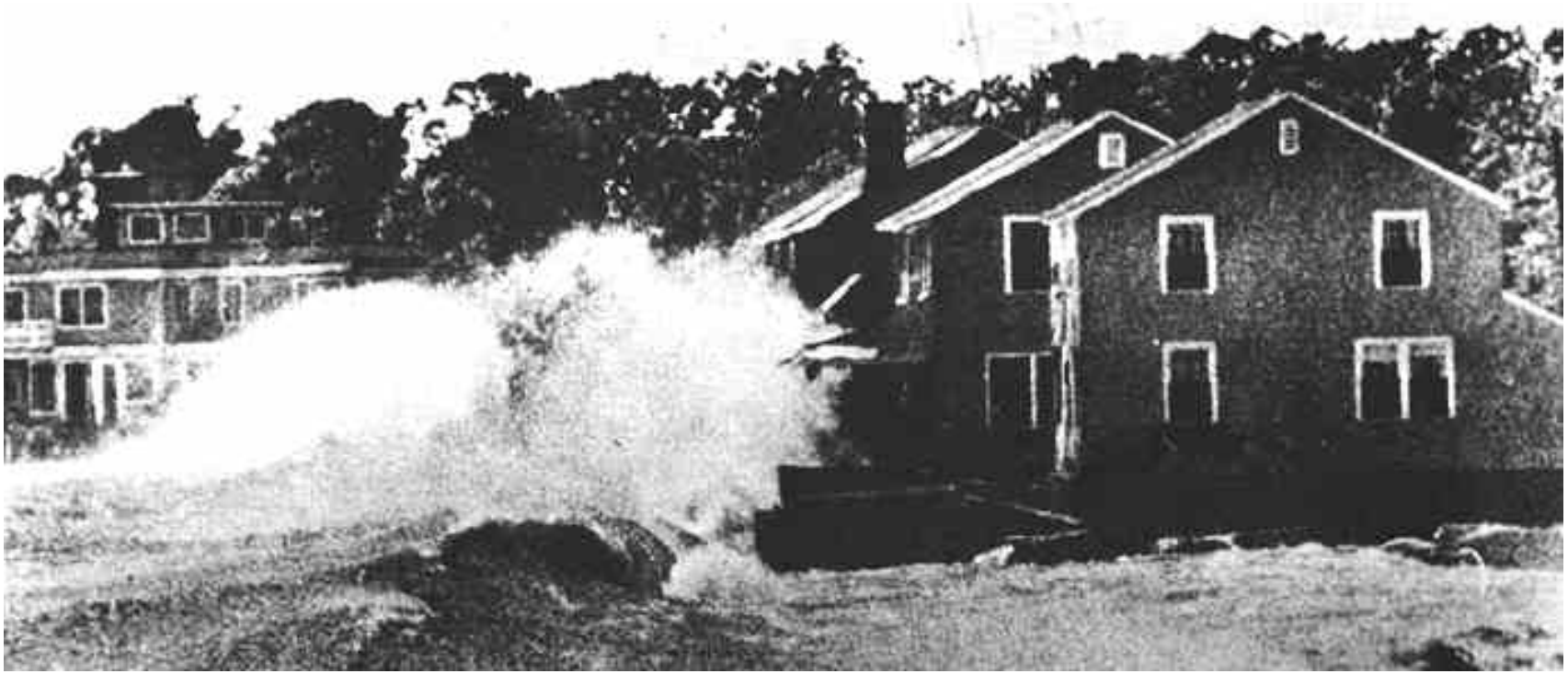
Hurricane Carol 1954

- Along the Outer Cape, a storm surge of at least 13-feet (with 10-foot waves) created a 20-foot wall of water that swept away buildings, homes, cottages, and businesses.

- Weeks after the storm, piles of wreckage could be seen for miles along Route 6 in southeastern Massachusetts.


U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
NORTH ATLANTIC HURRICANE TRACKING CHART

The Edgewood Yacht Club in Rhode Island is submerged by Hurricane Carol's storm surge in 1954. *(Photo C. Flagg)*.



Giant waves crash against the second floor of oceanfront homes in Old Lyme, Connecticut during Hurricane Carol in 1954. Tides along the eastern Connecticut coast reached 8 feet above normal (Photo NOAA Photo Library).

Summary

- We are in active era of more Atlantic Basin hurricanes due to the warm mode of the AMO.
- This is likely to be a La Nina summer in a warm Atlantic era. Remember each year that that occurred resulted in at last one east coast landfall (15 storms in the 9 years. 11 of them major CAT 3-5 storms)
- Since the warm Atlantic mode began in 1995, we have escaped a direct hurricane hit in the northeast but our luck could/will eventually run out
- We should hope for the best but PREPARE for the worst. Even with satellites and models we may only get a day or two warning of a direct hit
- Remember New Orleans was made aware they were especially vulnerable for the big one, it still ‘snuck up on them’

2007 Season

- Dr. Bill Gray's April Forecast:
  - 9 hurricanes (average is 5.9)
  - 17 named storms (average is 9.6)
  - 5 intense (Category 3-4-5) hurricanes (average is 2.3)
  - The probability of U.S. major hurricane landfall is estimated to be about 74 percent (last century average is 52%)
  - East Coast major CAT3+ landfall probability including Florida is 50% (last century average was 31%)