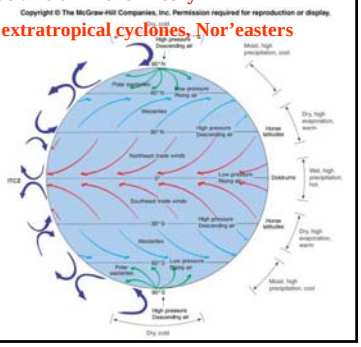
Chapter 5: Weather Systems

Norwegian Cyclone Model: Polar Front Theory

Mid Latitude Cyclones: extratropical cyclones, Nor'easters

Hurricanes

Storm Surge



Mid-latitude Cyclone:

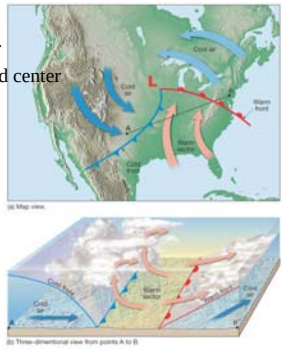
-primary weather producers

-low pressure systems, 1000 km dia.

-counterclockwise circulation toward center

-warm and cold **fronts**

-upward flow initiates precipitation



Fronts:

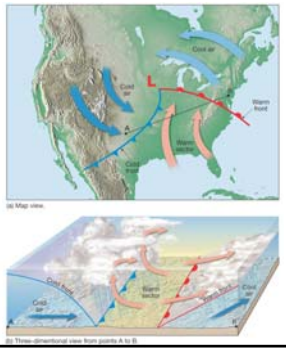
-boundary surfaces that separate air masses of different densities

temperature

moisture

-15-200km wide

-line on the weather map



Fronts:

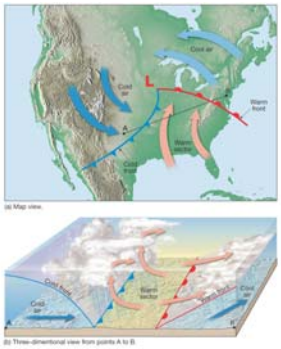
-surface **slope is gradual**

-warm air overlies cold air

-air masses move at different speeds

-one air mass will **advance**

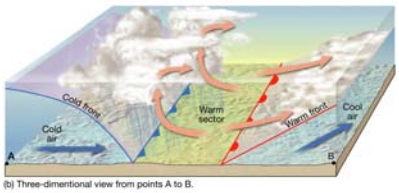
-clashing produces weather



Fronts:

-warm air is always forced **aloft**

-**overrunning**: warm air gliding on top of cold air



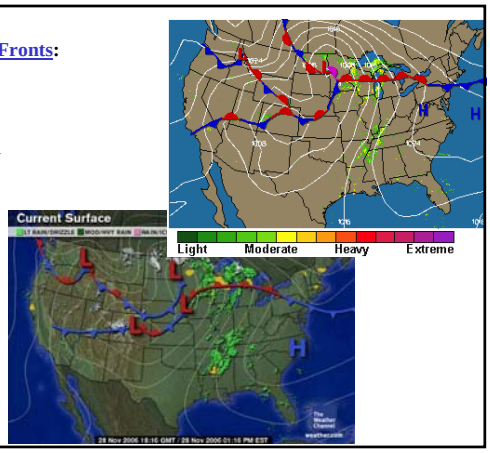
5 Types of Fronts:

-warm

-Cold

-Stationary

-Occluded



Occluded Front:

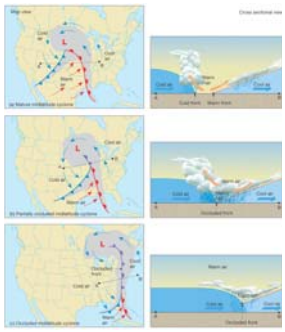
-rapid moving **cold front** overtakes a **warm front**

-warm air driven aloft

-precipitation from wedging

-strong temperature gradients

-intense weather



Life of a Midlatitiude Cyclone (2-10 days)

6 basic stages

Front develops

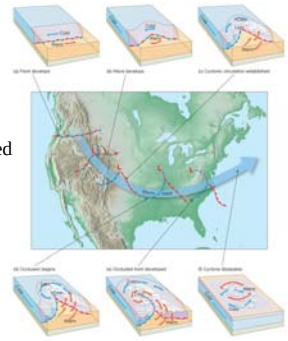
Wave develops

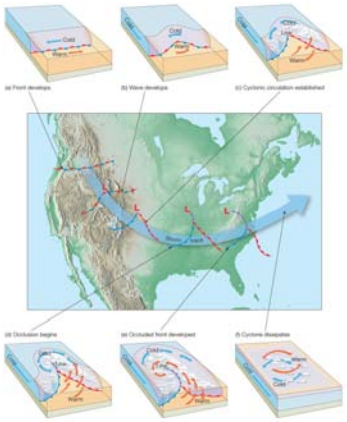
Cyclonic circulation established

Occlusion begins

Occluded front developed

Cyclone dissipates



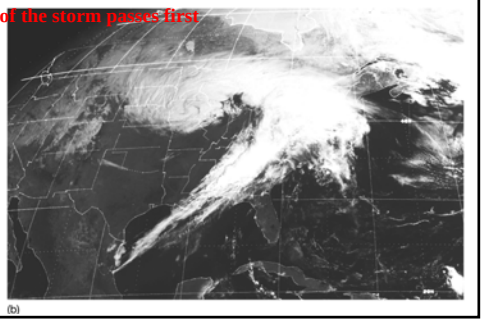


Idealized Weather of a Mid-latitude Cyclone

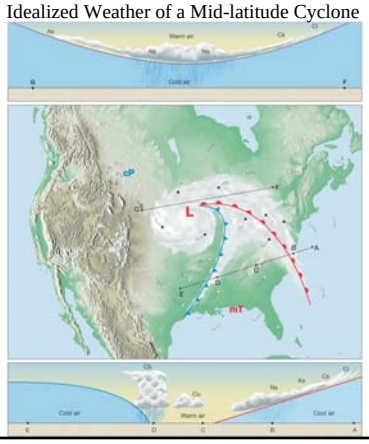
Cyclone generally move from west to east

Steered by the general westerly circulation

Right side of the storm passes first

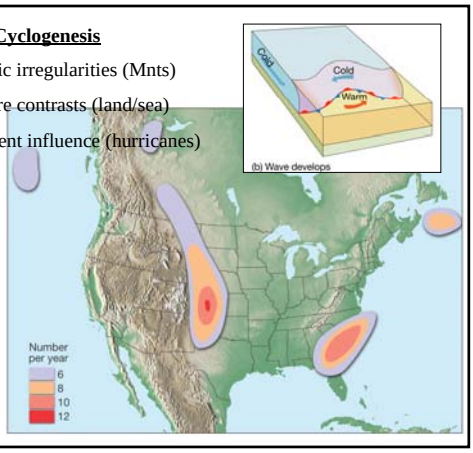


Idealized Weather of a Mid-latitude Cyclone



Regions of Cyclogenesis

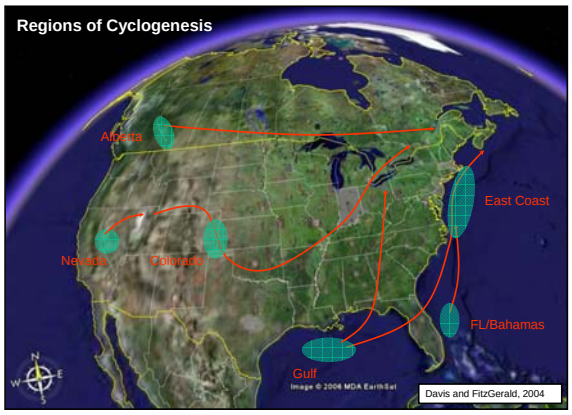
- Topographic irregularities (Mnts)
- Temperature contrasts (land/sea)
- Ocean current influence (hurricanes)



Storm Tracks: Patterns of Movement

In general east to northeast track

Most of the north Pacific storms that influence the west coast do not make it over the Rockies in tact (redevelop)

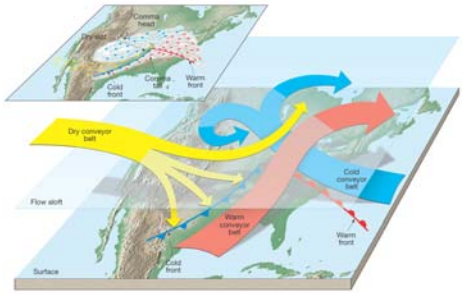


Modern View: The Conveyor Belt Model

3 intersecting air streams (belts)

2 belts originate at the surface and ascend

1 belt originates aloft and descends

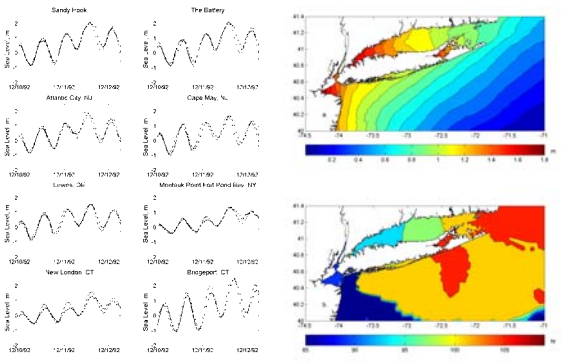


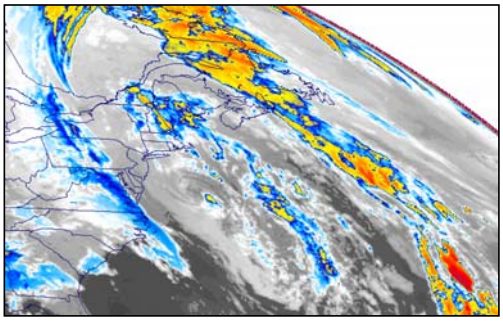
Nor'easters

November 1950 La Guardia Airport

FDR Drive December 1992

Ref: Bloomfield, J., M. Smith and N. Thompson, 1999. *Hot Nights in the City*. Environmental Defense Fund, NY.





The Perfect Storm (12 UTC October 31,1991)

Nor'easter Intensity Scale

1347 Hindcast Storms Off North Carolina (1942-1984)

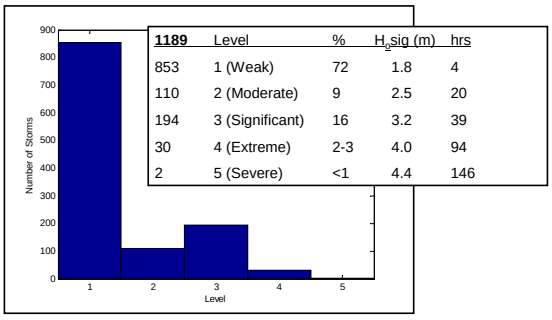
Relative Power = $(H_{osig}(m))^2$ x Storm Duration (hr)

Storm Class	$H_o$sig (m)	Duration (hrs)	Range (m^2hr)
1 Weak	2.0	8	Power <= 71
2 Moderate	2.5	10	71 < Power <= 163
3 Significant	3.3	34	163 < Power <= 929
4 Severe	5.0	63	929 < Power <= 2322
5 Extreme	7.0	96	Power > 2322

Dolan & Davis, 1992, Journal of Coastal Research.

1991 - 2005

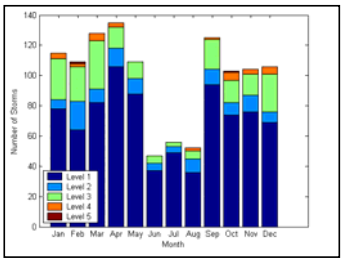
Nor'easter Intensity Scale



1189	Level	%	$H_s$sig (m)	hrs
853	1 (Weak)	72	1.8	4
110	2 (Moderate)	9	2.5	20
194	3 (Significant)	16	3.2	39
30	4 (Extreme)	2-3	4.0	94
2	5 (Severe)	<1	4.4	146

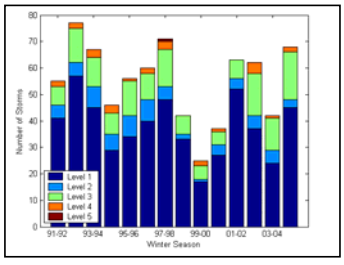
General Observations by Month

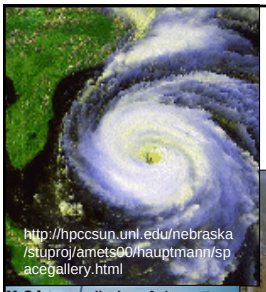
Number of Storms:	April (135)	March (128)	September (125)
Level 3 Storms (194):	March (32)	January (27)	December (25)
Level 4 Storms (30):	March, October, December (5)		January (4)



General Observations by Winter Season (Oct-Apr)

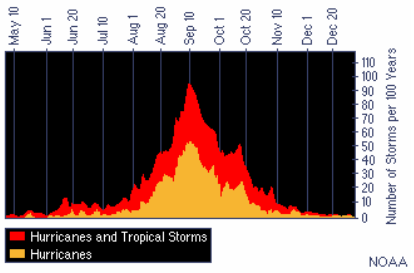
Number of Storms:	92-93 (77)	97-98 (71)	04-05 (68)
Level 3 Storms (194):	04-05 (18)	02-03 (16)	97-98 (14)
Level 4 Storms (30):	02-03 (4)	93-94, 94-95, 97-98 (3)	
Severe Winters:	97-98 (14,3,1)	02-03 (16,4)	04-05 (18,2)



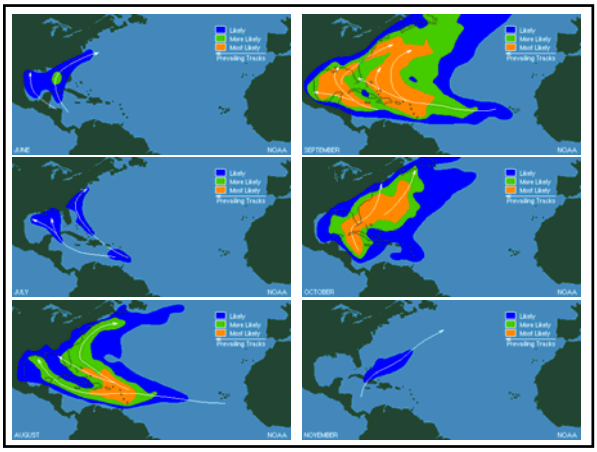


HURRICANES

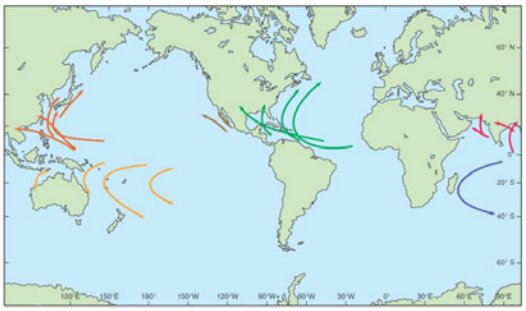
Most information taken from the Tropical Prediction Center (National Hurricane Center)
http://www.nhc.noaa.gov/



The official hurricane season for the Atlantic Basin (the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico) is from 1 June to 30 November.



Hurricanes can form on either side of the equator but not at the equator because the coriolis effect is zero



Western Pacific Ocean = typhoons or cyclones

www.accuweather.com

Hurricane Development

(from www.accuweather.com)

Step 1

Tropical Wave: "bump" or disruption of normal tropical easterly flow. Associated turning of wind causes low-level convergence of air; which helps with falling pressure and enhanced showers.

Step 2

This can evolve into a **Tropical Depression**, which is a closed circulation of air in the low levels. This in turn increases convergence and pressure falls, and wind speeds increase in a Catch-22 effect (i.e. the stronger the wind blows the greater the convergence, the quicker the pressure falls... so the stronger the wind, etc.).

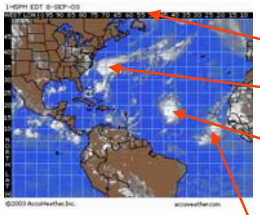
Step 3

Once sustained winds reach 39 mph in the closed circulation a **Tropical Storm** is named. Usually there are at least 2 closed isobars of 4 mb increments around the center. If atmospheric conditions remain correct the system will evolve into a...

Step 4

Hurricane. There is usually a difference in pressure of at least 0.60 inches of mercury between the center and surrounding pressure field, with the greatest change near the center (eyewall). It is this great difference in pressure, which sometimes can be as great as 2.95 inches of mercury, that causes the wind to be so strong.

Step 5
A mature hurricane is a well-oiled meteorological machine, but disruption of the processes that drive the storm (i.e. interaction with land or colder air feeding in) will begin to destroy the storm, and the **disintegration of a hurricane** can often be quick and dramatic.



Sep 8 2003 (www.accuweather.com)

Hurricane Fabian: 50 north, 39 west

Tropical Storm Henri 33 north, 76 west

Hurricane Isabelle is way out in the Atlantic, more than 1,200 miles east of the Leeward Islands, as of 11 a.m. AST. Isabel has strengthened to a category 3 hurricane, with 115-mph maximum sustained winds, and is moving west-northwest at 14 mph. This motion will take Isabel near or north of the Leeward Islands on Friday

Tropical Depression #14

Sep 15 2003 (www.accuweather.com)

Hurricane Isabelle has weakened a bit with 140-mph sustained winds, and hurricane-force winds extend as far as 115 miles from the center. Isabel is a dangerous, strong category 4 hurricane. The central pressure is estimated at 945 mb (27.76 inches). Isabel has also slowed down a bit and is moving west-northwest at 8 mph. It seems, looking at the steering pattern, that Isabel will strike the East Coast of the U.S. As we see it now, the area from North Carolina to New Jersey is the target of landfall; most likely the Delmarva Peninsula.

Saffir-Simpson Scale

The chart color codes intensity (category based on Saffir-Simpson scale):

Type	Category	Pressure (mb)	Winds (knots)	Winds (mph)	Surge (ft)	Line Color
Depression	TD	-----	< 34	< 39		Green
Tropical Storm	TS	-----	34-63	39-73		Yellow
Hurricane	1	> 980	64-82	74-95	4-5	Red
Hurricane	2	965-980	83-95	96-110	6-8	Light Red
Hurricane	3	945-965	96-113	111-130	9-12	Magenta
Hurricane	4	920-945	114-135	131-155	13-18	Light Magenta
Hurricane	5	< 920	>135	>155	>18	White

NOTE: Pressures are in millibars and winds are in knots where one knot is equal to 1.15 mph.

http://weather.unisys.com

New York Metro Area

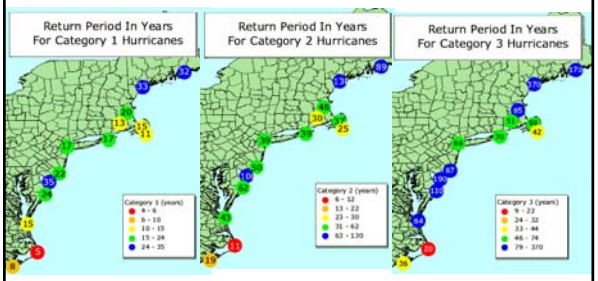
22 million people

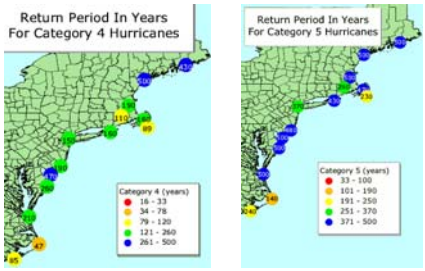
13,000 mi² (34,000 km²)

Top 10 worst places for an extreme hurricane to strike

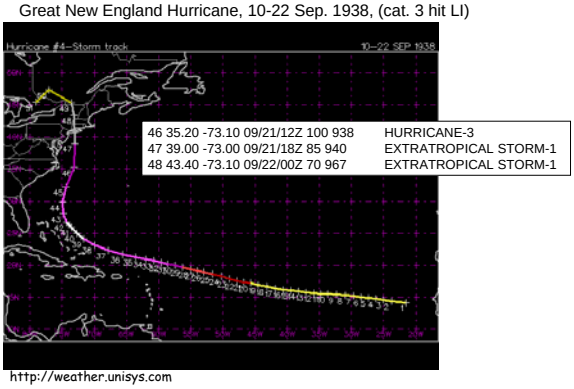
Rank	Location	Possible insured losses*	Potential total economic losses**
1	Miami/Ft. Lauderdale, Fla.	$61.3 billion	$122.6 billion
2	New York City, N.Y.	$26.5 billion	$53 billion
3	Tampa/St. Petersburg, Fla.	$25.1 billion	$50 billion
4	Houston/Galveston, Texas	$16.8 billion	$33.6 billion
5	New Orleans, La.	$8.4 billion	$16.8 billion
6	Mobile, Ala.	$6.0 billion	$12 billion
7	Boston, Mass.	$5.1 billion	$10.2 billion
8	Biloxi/Gulfport, Miss.	$5.1 billion	$10.2 billion
9	Myrtle Beach, S.C.	$4.3 billion	$8.6 billion
10	Norfolk, Va.	$3.9 billion	$7.8 billion

http://www.climate.org/topics/weather/new_york_severe_storm_threat.shtml





Great New England Hurricane, 10-22 Sep. 1938, (cat. 3 hit LI)



http://weather.unisys.com

NY District, USACE

Reported Impacts

Formation of new inlets

Overwash and destruction of sand dunes

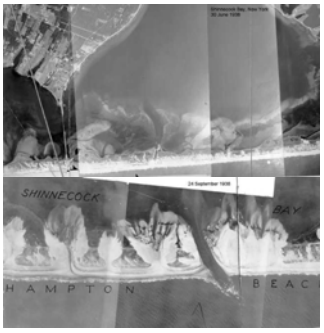
-18 ft above msl

Observed Storm Surge (ft)

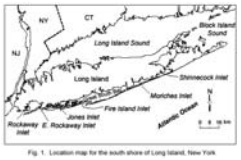
Montauk Point	14.7
Westhampton	11.9
Rockaway	9.7

War Department
Beach Erosion Board, 8/6/46

Barrier Island Breaching

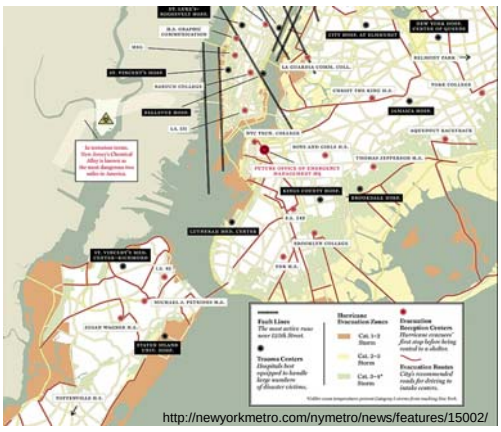


6/30/38

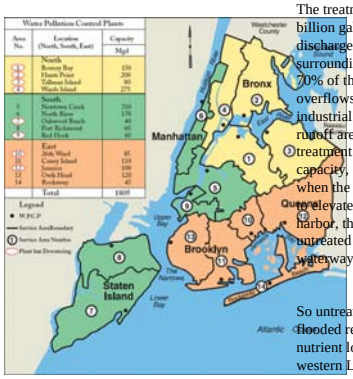


9/24/38

Shinnecock Inlet

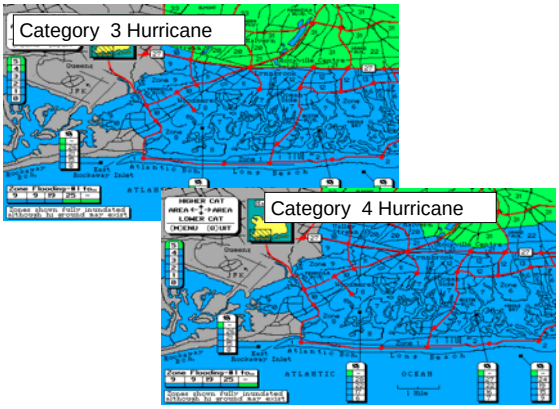


http://newyorkmetro.com/nymetro/news/features/15002/

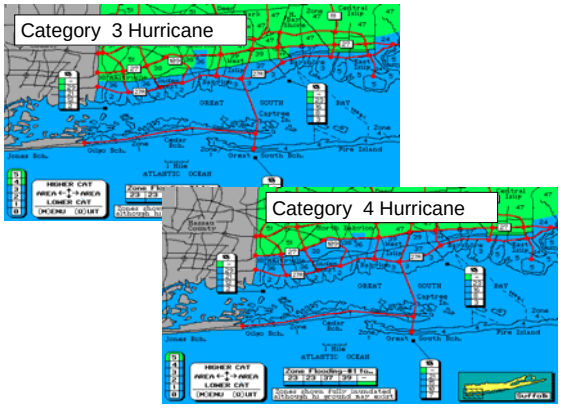


The treatment facilities process over 1.4 billion gallons of wastewater daily, and discharged the effluent, into the waterways surrounding New York City. Approximately 70% of the city's sewers are combined sewer overflows (CSO), in which sanitary and industrial wastewater, rainwater and street runoff are collected and transported to the treatment plants. When the CSOs fill to capacity, due to heavy rainfall or snow, or when the treatment facilities are disabled due to elevated water levels throughout the harbor, the mix of excess storm water and untreated sewage flows directly into the City's waterways.

So untreated sewage could end up on the flooded regions of the city, add the high nutrient load could result in anoxic events in western LI sound



http://www2.sunysuffolk.edu/mandias/38hurricane/storm_surge_maps.html



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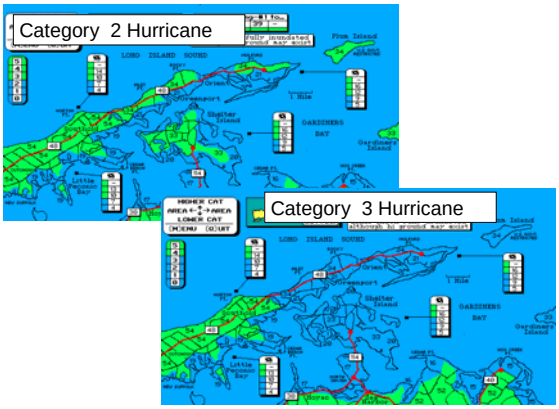

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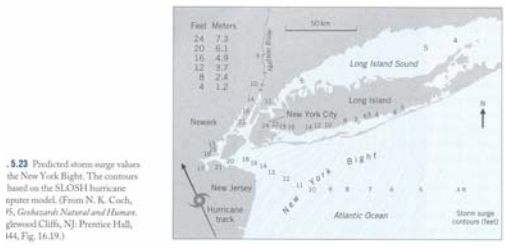
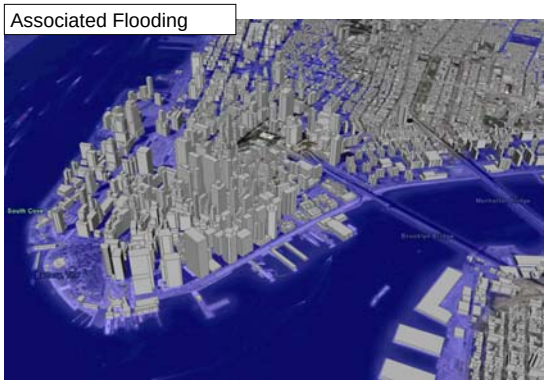


5.23 Predicted storm surge values in the New York Bight. The contours are based on the SLOSH hurricane model. (From N. K. Coch, *Geohazards: Natural and Human*, Englewood Cliffs, NJ: Prentice Hall, 1994, Fig. 16.19.)

Moderately sized Hurricane (3-4), importance of storm track

Associated Flooding



Associated Flooding