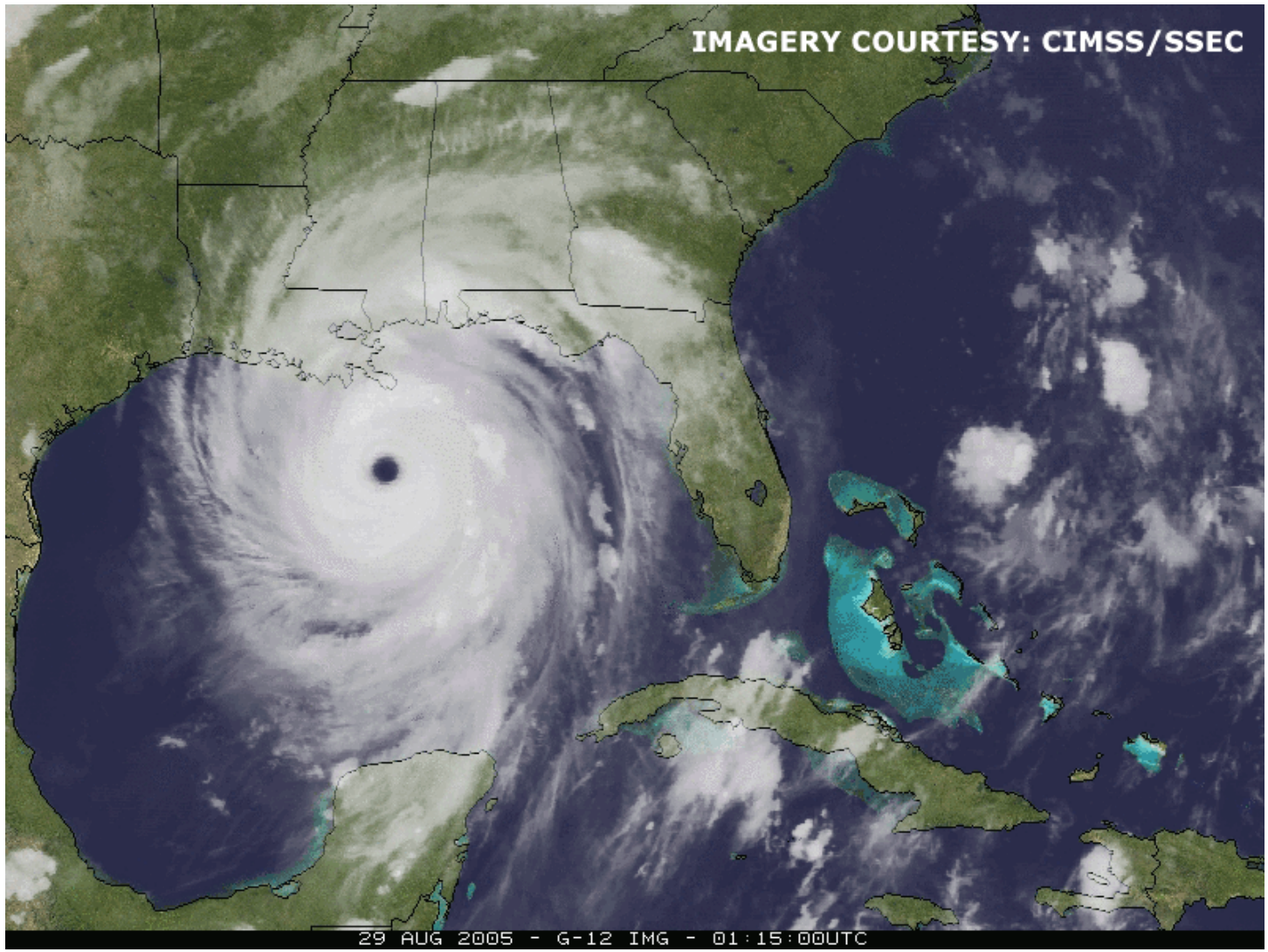
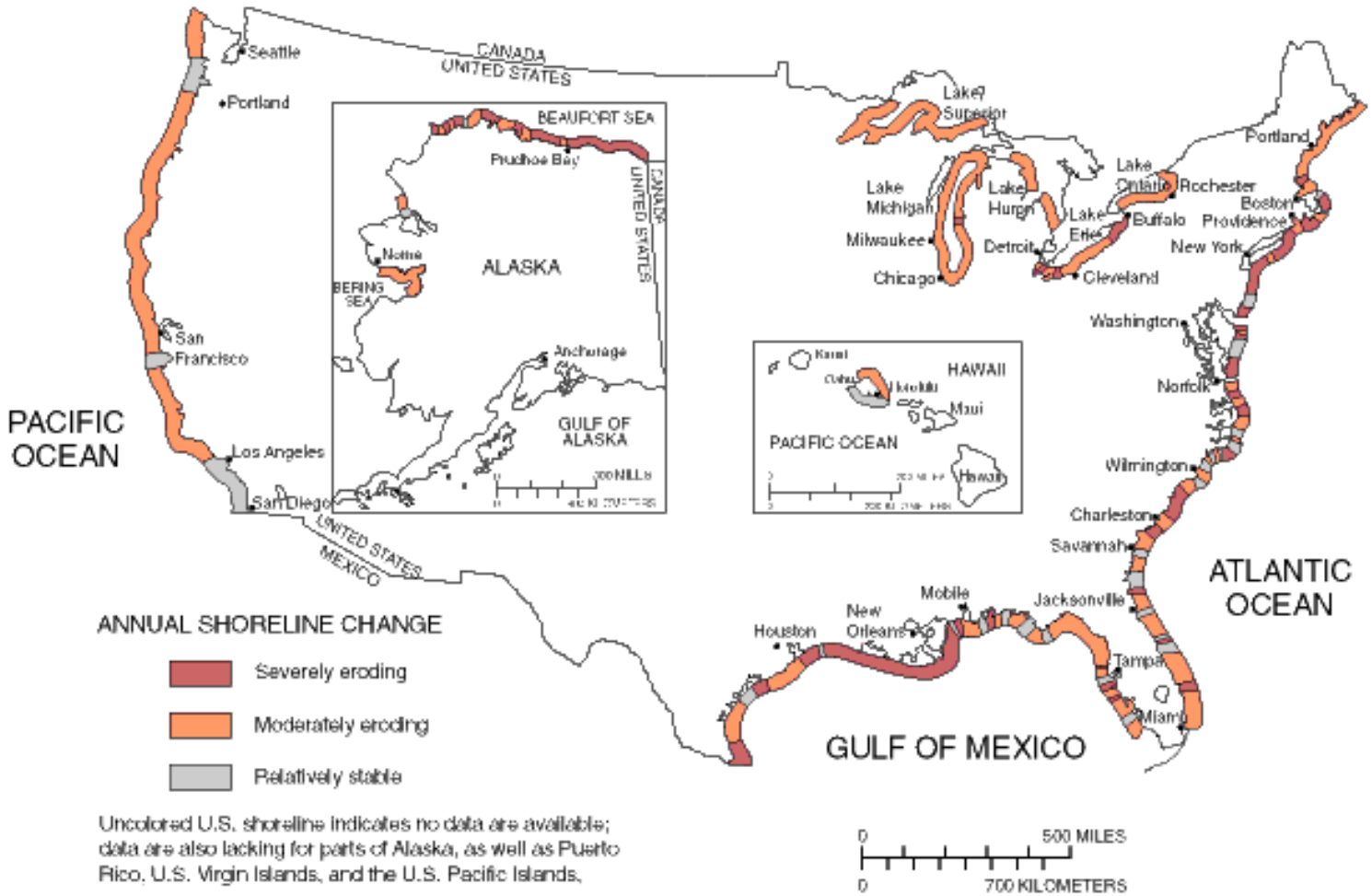
Controlling Coastal erosion



Coastal Erosion Rates in the U.S.



Coastal Erosion and Stabilization

Economic pressures demanding the “stabilization” of beaches and coastlines are immense

Coastal Erosion and Stabilization

There are three major approaches used by humans to try and solve the problem of coastline erosion

Hard structural stabilization such as groins, jetties seawalls and breakwaters

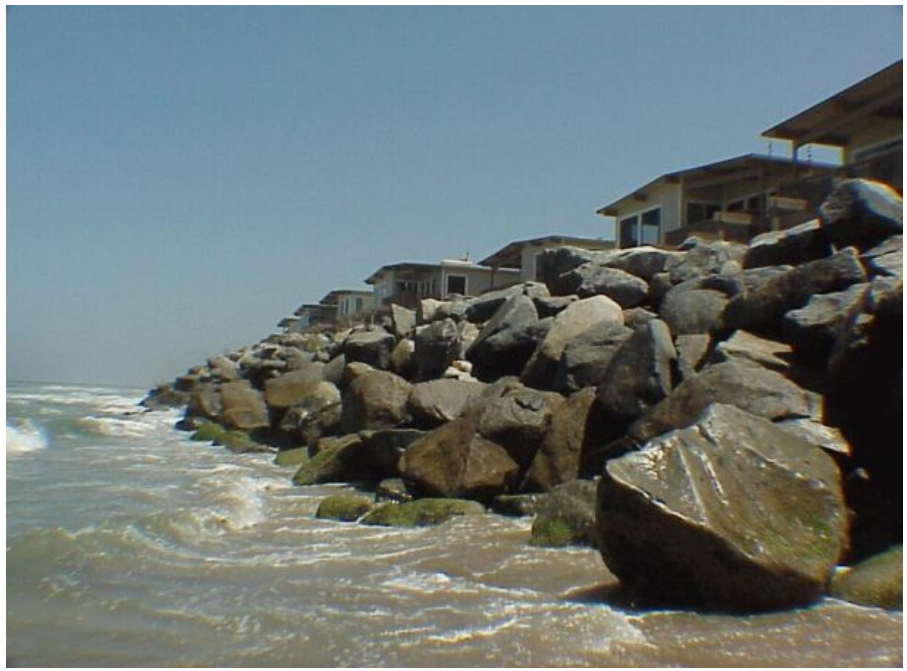
Soft structural stabilization such as beach nourishment

Nonstructural strategies such as land-use restriction and zoning

In the long run, only one of these approaches really works...

Hard Structural Stabilization

Federal, state and local governments have had long-term love affairs with groin, jetty, seawall and breakwater structures



Groins

Groins are impermeable structures that extend, fingerlike, perpendicularly from the shore

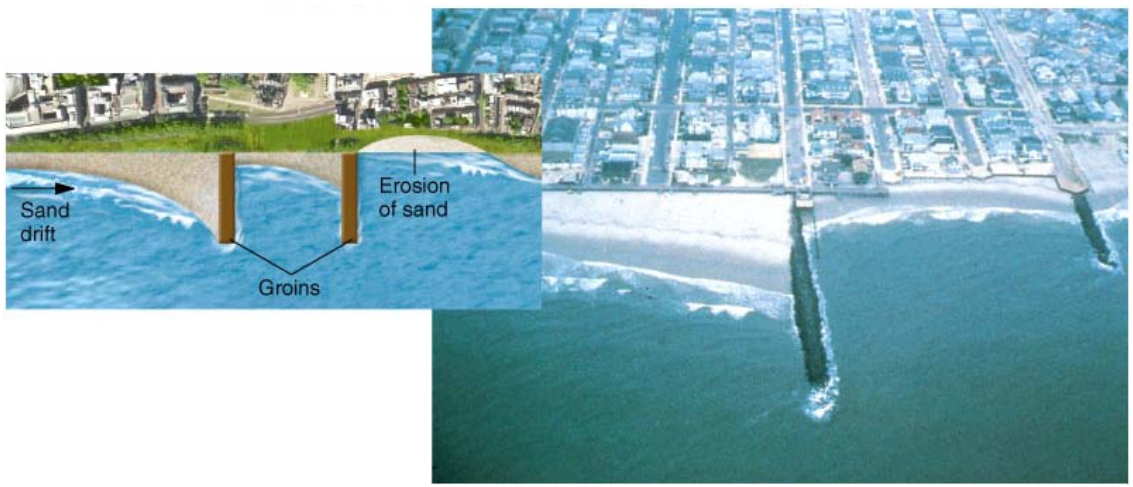
Usually constructed in groups called groin fields, their primary purpose is to trap and retain sand, nourishing the beach between each groin

They are most effective where the longshore current is predominantly in one direction, and where their action will not cause unacceptable erosion of the downdrift shore

Groins

By disrupting the normal ocean current flow, the physical shape of the beach is changed

The common result is that a formerly stable, straight shoreline develops an unnatural scalloped shape



Groins

Sand deposition is greatly increased on the up-current side of the groin

Meanwhile on the down-current side of the groin, sand erosion is greatly increased

Groins

Deposition on the up-current side

Erosion on the down-current side

CURRENT DIRECTION

Jetties

A pair of jetties are used to stabilize the channel where harbors, rivers, lagoons and estuaries open out into the ocean

For example, this allows boats and ships to safely enter the channel into a harbor

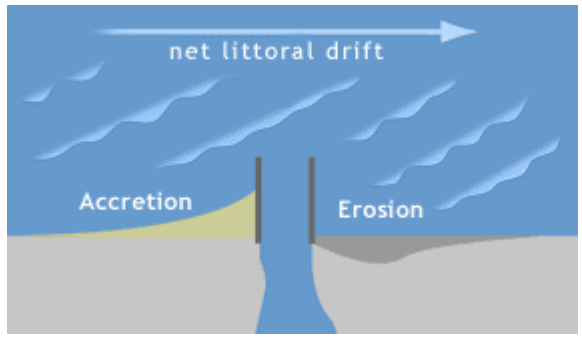
In addition, jetties are used to protect and stabilize man-made constructions such docks, piers and other maritime works

In Russia, jetties were used to create harbors in the land-locked Baltic Sea

Jetties

Harbors, rivers, lagoons and estuaries typically have entrances that migrate through time

A pair of jetties are constructed to try and stabilize the entrance



Jetties

Sand flow at the Indian River inlet in Delaware was blocked by these jetties causing major erosion

Sand has to be continuously piped across the inlet from the wide beach to the narrow one, to help reverse erosion

Seawalls

A **seawall** is a hard structure constructed on the inland part of a coast to reduce the effects of strong waves and to defend the coast around a town or harbor from erosion

The walls can be sloping, vertical or curved to reflect wave power

Seawalls are effective defenses in the short term, but may cause erosion in the long run

Seawalls

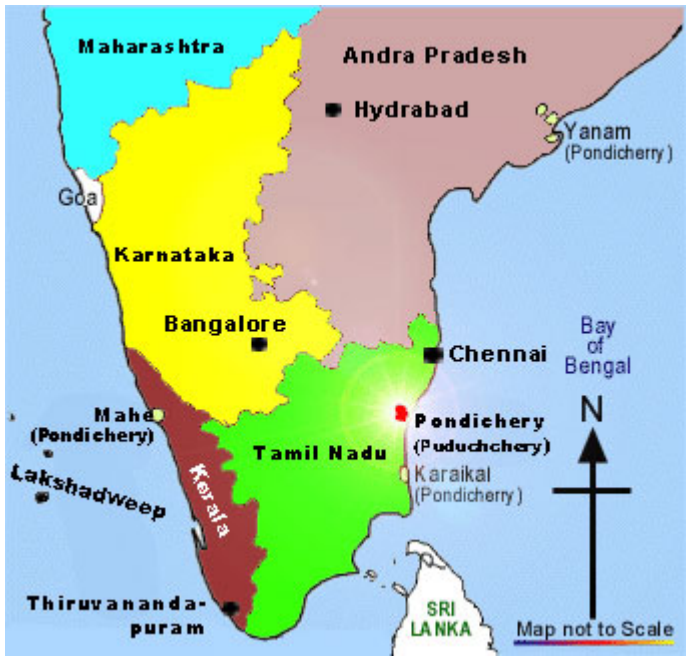
The backwash of the breaking waves cause the sand and sediments in front of the seawall to erode away

Seawalls

During high tides and storms, the waves break with their full energy directly onto the seawall

Pondicherry, India

On December 26, 2004, when towering waves of the 2004 Indian Ocean tsunami crashed against India's south-eastern coastline killing thousands, the former French colonial enclave of Pondicherry (now Puducherry) escaped unscathed



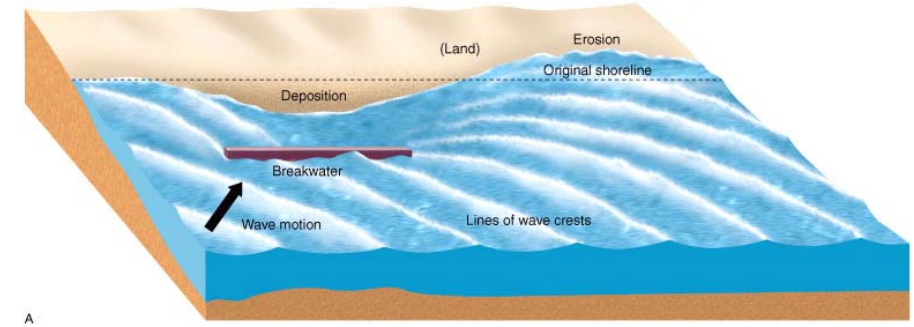
Pondicherry, India

During the city's nearly three centuries as a French colony, French engineers had constructed and a massive 1.25 mile long, 27 foot high stone seawall

This seawall kept Pondicherry's historic center dry even though tsunami waves were 24 feet high

Breakwaters

Breakwaters are structures built parallel to a shoreline to protect an anchorage from the effects of weather and longshore drift



A


B

Breakwaters

Large breakwaters, such as this one in Portland, Oregon, provide safe haven in calm waters for ocean going vessels even during storms

Mankind Against the Sea

Of course, in the battle by mankind to stabilize the coastline, they commonly use more than one type of hard structures, such as in Belgium where groins, seawalls, levees and pumping stations are employed to protect farmland

Mankind Against the Sea

What do jetties, groins, seawalls, and breakwaters all have in common?

They all increase erosion

Therefore in the long run, they do not prevent a beach from eroding away...

Mankind Against the Sea

... but that has not stopped the wholesale construction of groins, jetties, seawalls and breakwaters all along the U.S. coastline

Soft Structure Stabilization

Beach Nourishment is the addition of sand and sediment to a beach to replace sand and sediment that has been eroded away

It involves the transport of the "nourishment material" from one area to the affected area

Of course, beaches sands and sediments are not living entities and do not require "nourishment"

Beach Nourishment

Advantages...

Beach nourishment restores and widens the recreational beach

Structures behind the beach are better protected as long as the added sand remains

When erosion continues, beach nourishment does not leave hazards on the beach or in the surf zone

Beach Nourishment

Disadvantages...

This is a very expensive process, costing over one million dollars per mile of beach

Miami Beach holds the expense record of 17.5 million dollars per mile of beach

Beach Nourishment

The beach is turned into a construction zone during nourishment for months

Beach Nourishment

The replacement sand added to the beach is often different from the natural beach sand.

This means that the new material may have smaller or larger diameter sand grains than the natural beach

Such differences in "grain-size" affect the way waves interact with a beach and causes a significant change the shape of the beach

You can always tell when you are on a man-made beach

Beach Nourishment

Beach nourishment sand usually erodes faster than the natural sand on the beach

A good rule of thumb is that nourished beaches erode two or three times faster than natural beaches

Beach Nourishment

The replacement sand is usually dredged up offshore and transported to the beach

Offshore “sand” is almost always much finer grained and muddier, therefore it erodes very quickly

Beach Nourishment

The beach at Ocean City, New Jersey was renourished 22 times in 43 years at a cost to the U.S. tax payers of $63 million

One Ocean City renourishment project was completely eroded away in 2 months

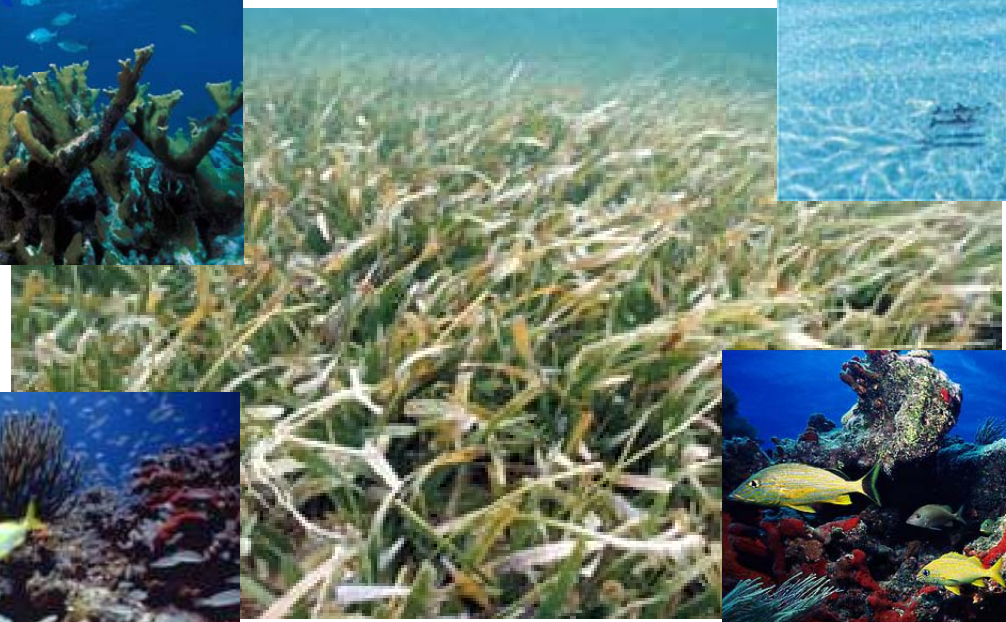
Beach Nourishment

The dredging associated with beach nourishment destroys, damages or otherwise hurts marine and beach life

The increased erosion muddies the water along the coast

Beach Nourishment

Biscayne National Park was seriously polluted by the Dade County beach nourishment



Nonstructural Strategies

Coastlines are dynamic, high energy environments where waves, storms and time always cause change

Both hard and soft structural stabilization, in the long run, require increased expenditure for fleeting gains

Nonstructural strategies such as land-use restrictions, prohibiting development and mandating minimum setback from the coast are the only way to minimize property damage

Such strategies are bitterly opposed by most local authorities

Unstable Coastal Environments

All coastal environments are unstable and change over time

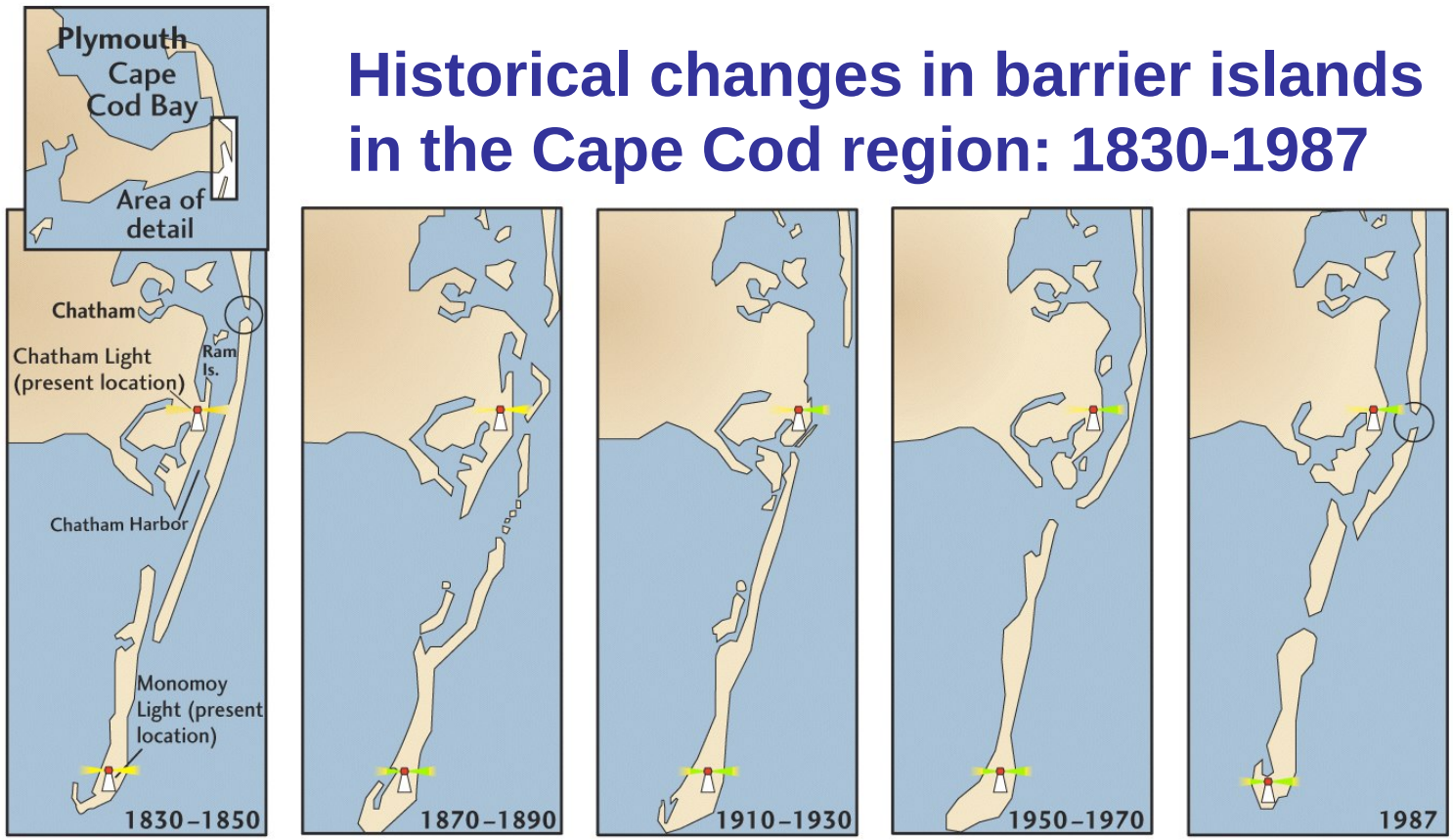
Two coastal environments, barrier islands and estuaries are very vulnerable to natural forces and human interference

Barrier Islands

Migrating barrier island, Cape Cod, Massachusetts

Barrier Islands

Historical changes in barrier islands in the Cape Cod region: 1830-1987



Circle shows approximate location of 1846 breach in barrier spit. Ram Island later disappears.

Beach south of the inlet breaks up and migrates southwest toward the mainland and Monomoy.

The southern beach has disappeared, and its remnants soon will connect Monomoy to the mainland.

The northern beach steadily grows with cliff sediment; Monomoy breaks from the mainland.

140-year cycle begins again with Jan. 2 breach in the barrier spit across from Chatham Light (circle).

Barrier Islands

A

B

An example of how even a near miss can significantly change barrier islands

A storm surge caused by Hurricane Fran in 1996 damaged and destroyed these home on the Outer Banks

Fran never actually came ashore

Barrier Islands

Bertha
7/16/1996

A

Fran
9/7/1996

B

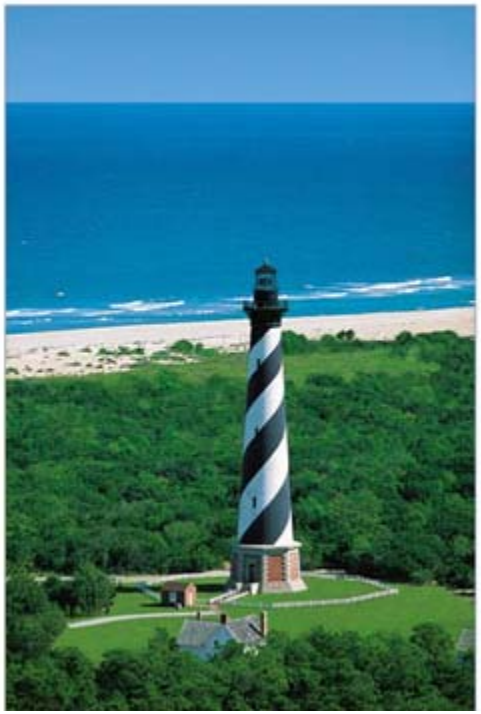
Bonnie
8/28/1998

C

After the passage of three hurricanes in a two year time span, this hotel has lost most of the beach front

Notice the small concrete seawall built to “protect” the hotel from the inlet

Barrier Islands



The famous Cape Hatteras Lighthouse was built in 1869

It was situated inland, safe from the Atlantic Ocean

It is the tallest lighthouse in the U.S. at 208 feet

The only way to the top are 268 steps

Barrier Islands

By the 1980s, it became obvious that beach erosion would eventually claim the lighthouse

Barrier Islands

So in 1999, after two decades of debate, the lighthouse was moved 2900 feet inland

A few week after the move was completed, Hurricane Dennis smashed into the Outer Banks

Estuaries

An estuary is a body of water along a coastline, open to the sea, in which the tides rise and fall and in which fresh and salt water mix

Estuaries

The complex community of plants and both marine and land animals that live is estuaries have adopted to the ever-changing environment of fresh and salt water

The is a delicate community, which is very vulnerable to pollution

Because water circulation is very limited, pollutants can accumulate

The greatest threat to estuaries is mankind

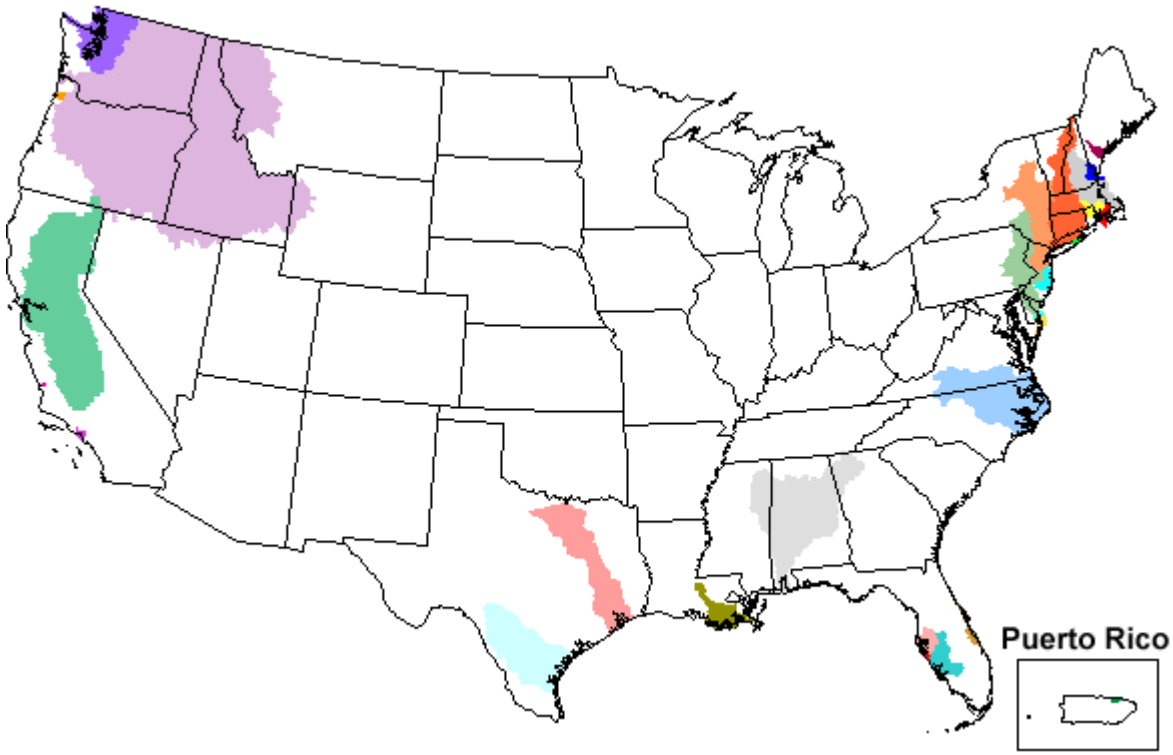
Estuaries

Where land is at a premium, estuaries are commonly filled in to create new land

Or fresh water is diverted

Estuaries

Map showing the river drainage basins that feed into major coastal estuaries in the U.S.



Zuider Zee

One of the most ambitious projects involving reclaiming land from the sea involves the Zuider Zee in the Netherlands

Zuider Zee

The Zuider Zee formed in 1282 when a sandbar was breached by a disastrous flood

Zuider Zee

Ocean water poured into an existing lake and flooded 5,000 square kilometers, creating an estuary that extended about 100 kilometers inland with an average depth of 4 to 5 meters

Zuider Zee

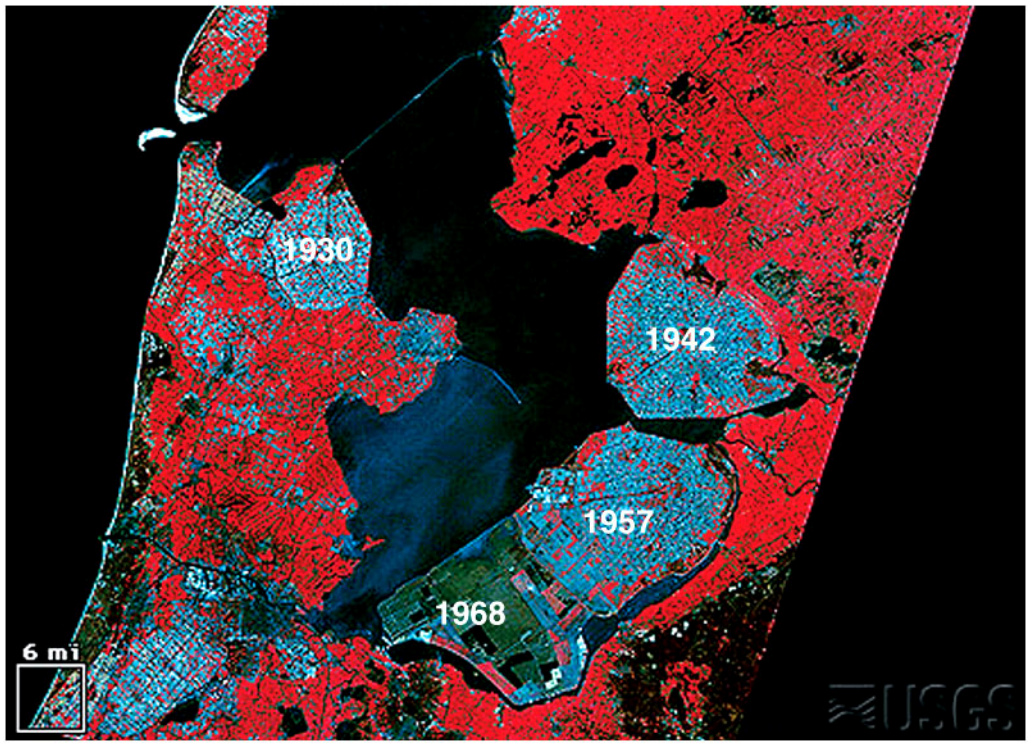
Two centuries later, with a growing population demanding more farmland, the Dutch began to reclaim the land from the sea

The estuary was dammed up

Fresh water continued to flow into the Zuider Zee and gradually changed the water from brackish to relatively fresh

Zuider Zee

Portions were filled in to create dry land, while other areas, called “polders”, were isolated by dikes and pumped dry



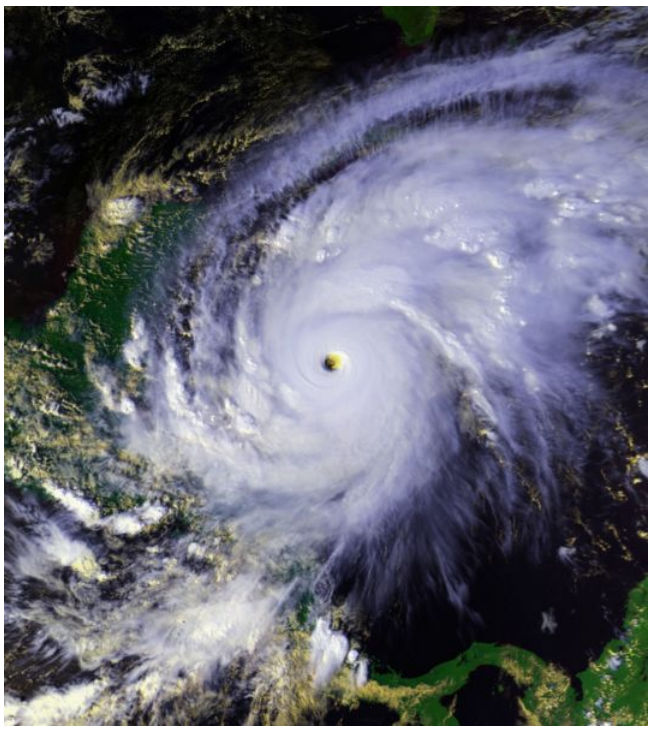
More than a half million acres of new farmland have been created

Zuider Zee

The 32 kilometer long “Afsluitdijk” (closure dike) separates the reclaimed land from the North Sea

How to Create a Hurricane

There are 6 major factors that help generate a hurricane:



Temperature

Rapid cooling

High humidity

Low wind shear

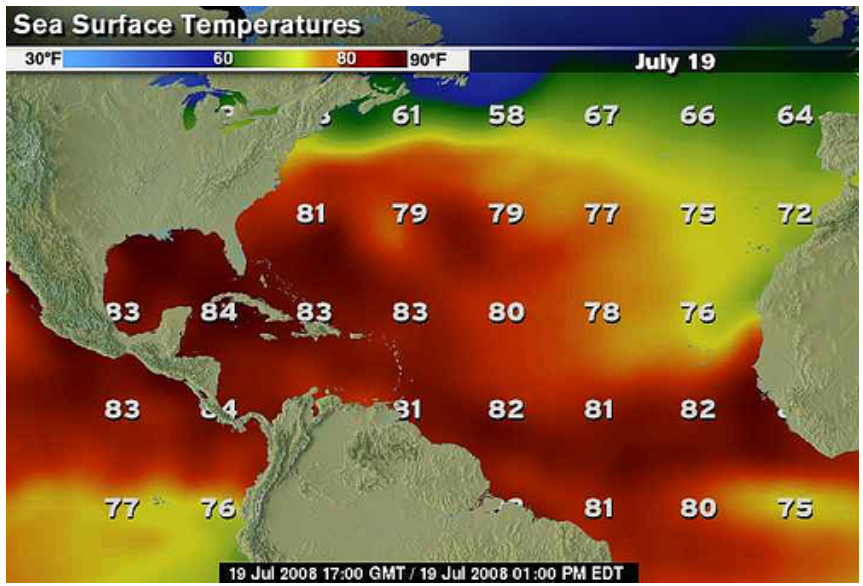
Location, location, location

Disturbed weather

How to Create a Hurricane

In most situations, water temperatures of at least 26.5 °C (79.7 °F) are needed down to a depth of at least 50 meters (160 ft)

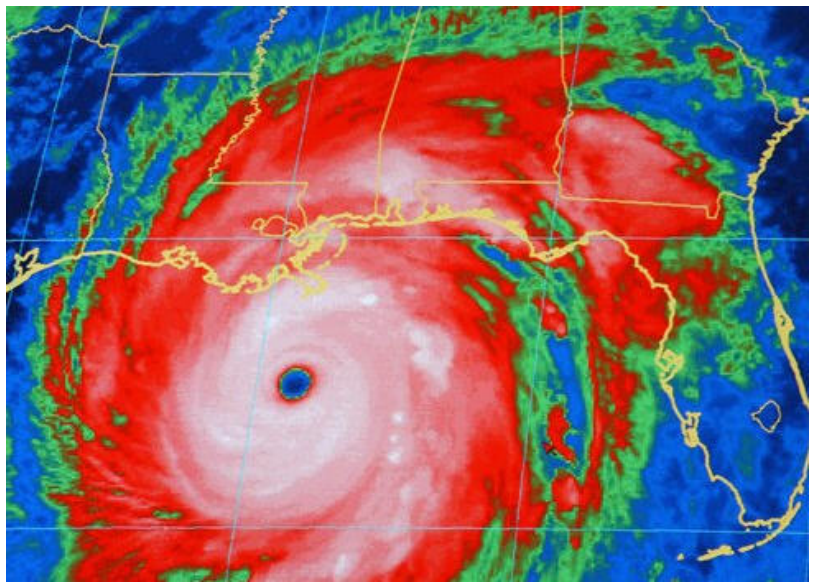
Waters of this temperature cause the overlying atmosphere to be unstable enough to sustain convection and thunderstorms



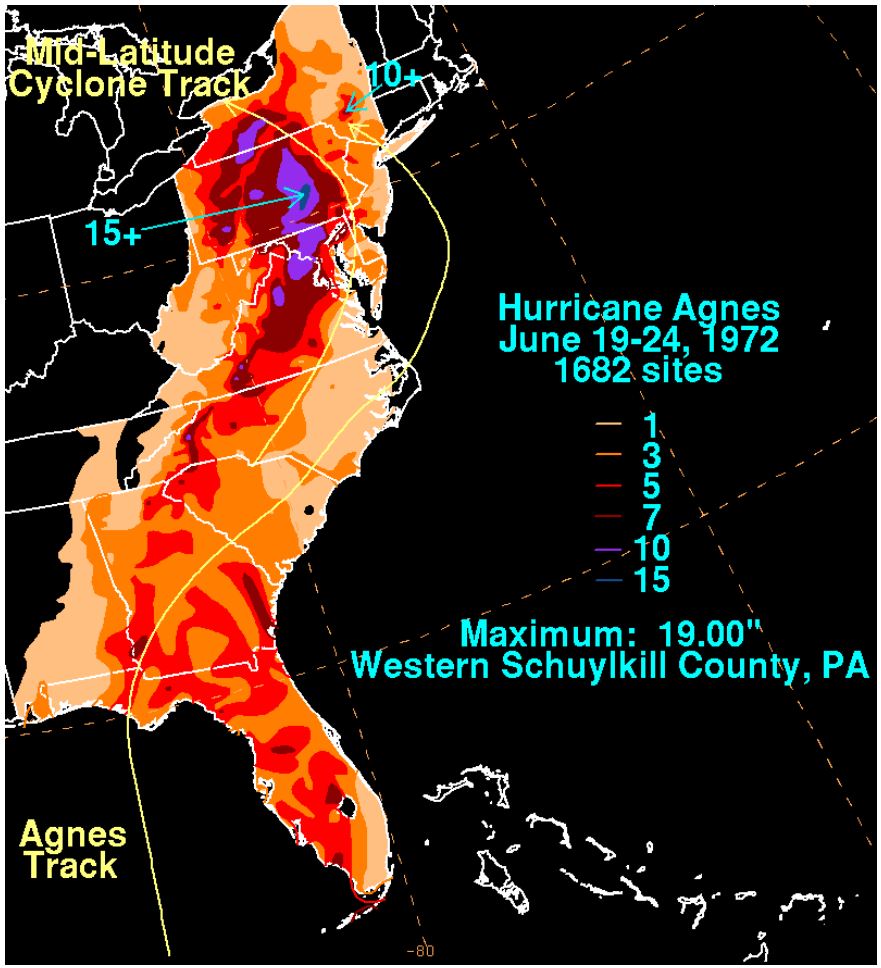
How to Create a Hurricane

An important factor is rapid cooling with height, which allows the release of the heat of condensation that powers a tropical cyclone

The heat of condensation is the energy required to transform a given quantity of a substance (water) into a gas (water vapor)



How to Create a Hurricane



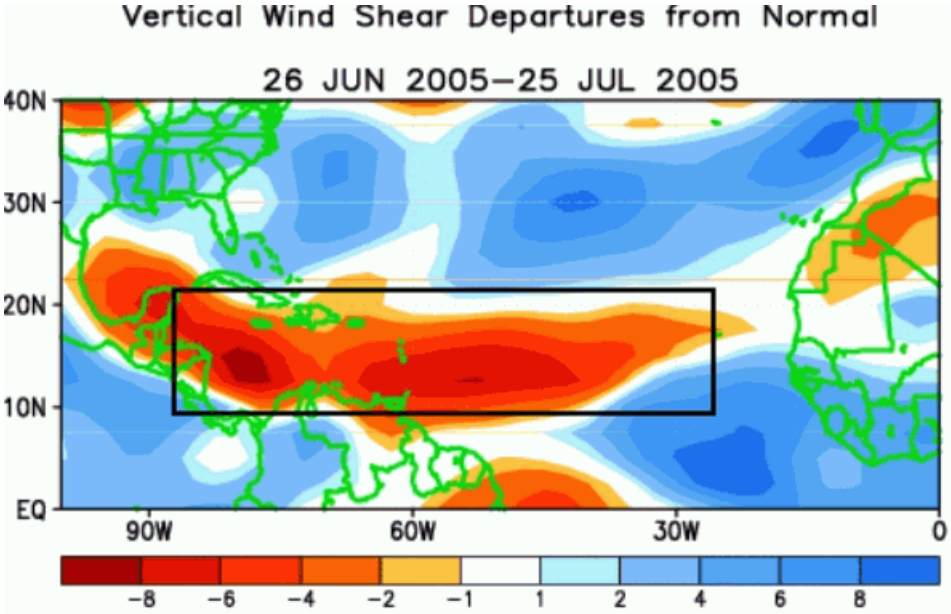
High humidity is needed, especially in the lower-to-mid troposphere of the atmosphere

When there is a significant amount of moisture in the atmosphere, conditions are more favorable for disturbances to develop

How to Create a Hurricane

Low amounts of wind shear are needed, as high shear is disruptive to the storm's circulation

Wind shear is a difference in wind speed and direction over a relatively short distance in the atmosphere



Red indicates areas with very low wind shear

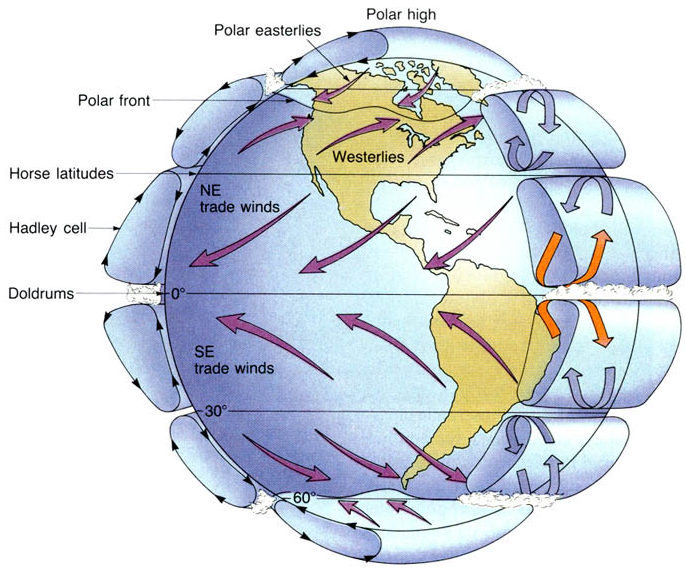
How to Create a Hurricane

Tropical cyclones generally need to form more than 555 kilometers (345 miles) or 5 degrees of latitude away from the equator, allowing the Coriolis effect to deflect winds blowing towards the low pressure center and creating a circulation

How to Create a Hurricane

Because the Earth rotates, the Coriolis effect causes winds and water currents to flow to the west near the equator

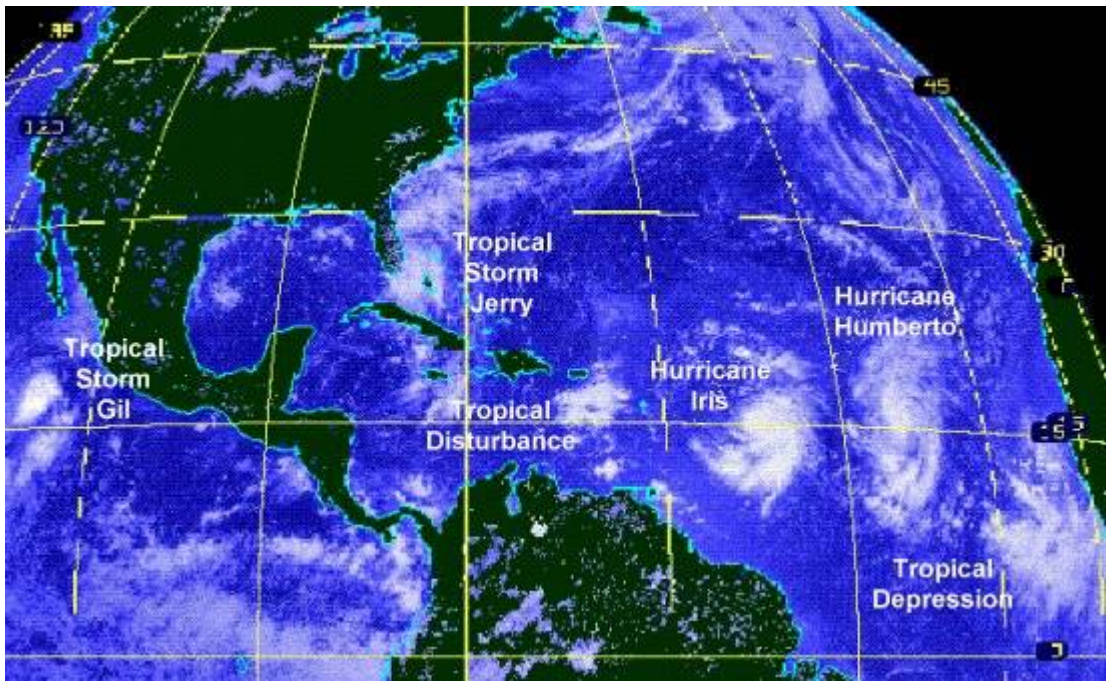
This effect is responsible for the rotation of large tropical storms (hurricanes, typhoons & cyclones)



How to Create a Hurricane

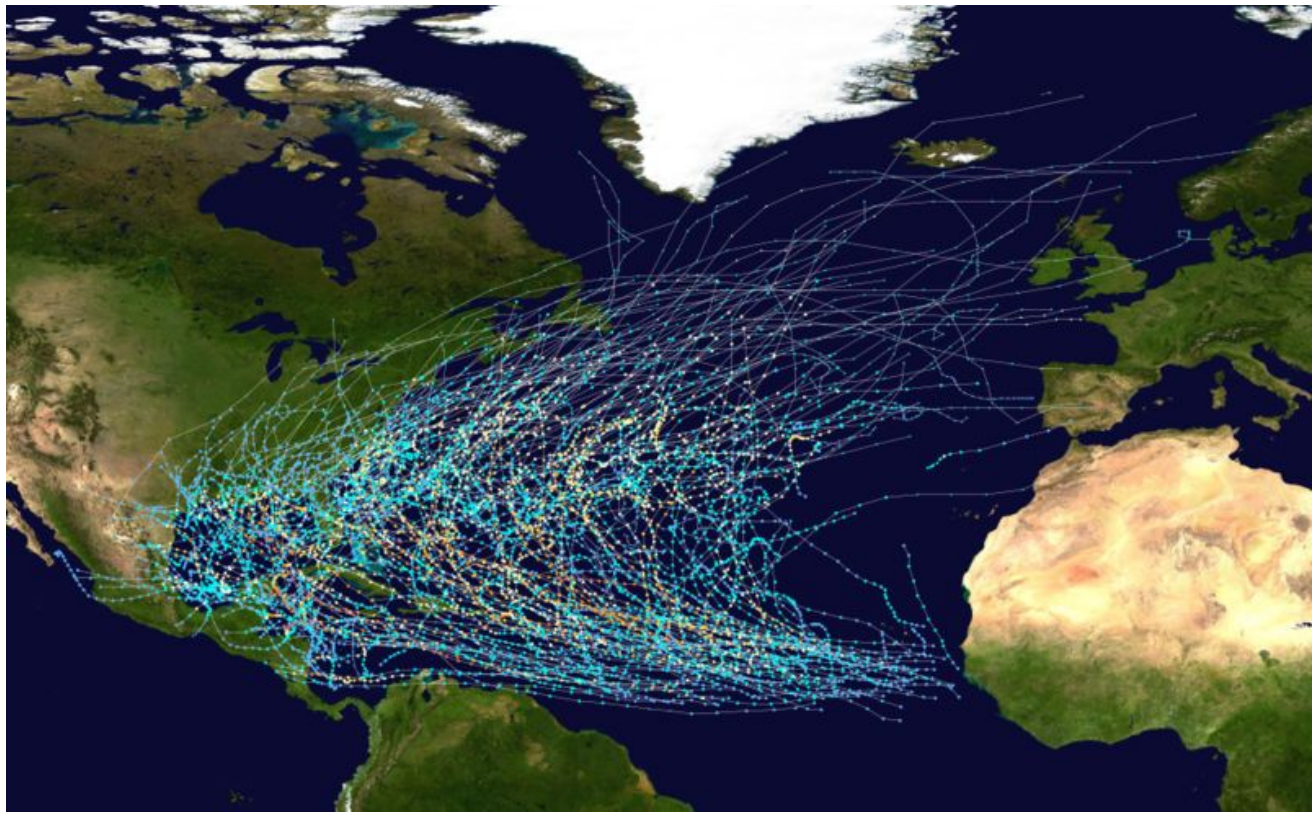
A formative hurricane needs a pre-existing system of disturbed weather

A tropical depression becomes a tropical storm and finally a hurricane



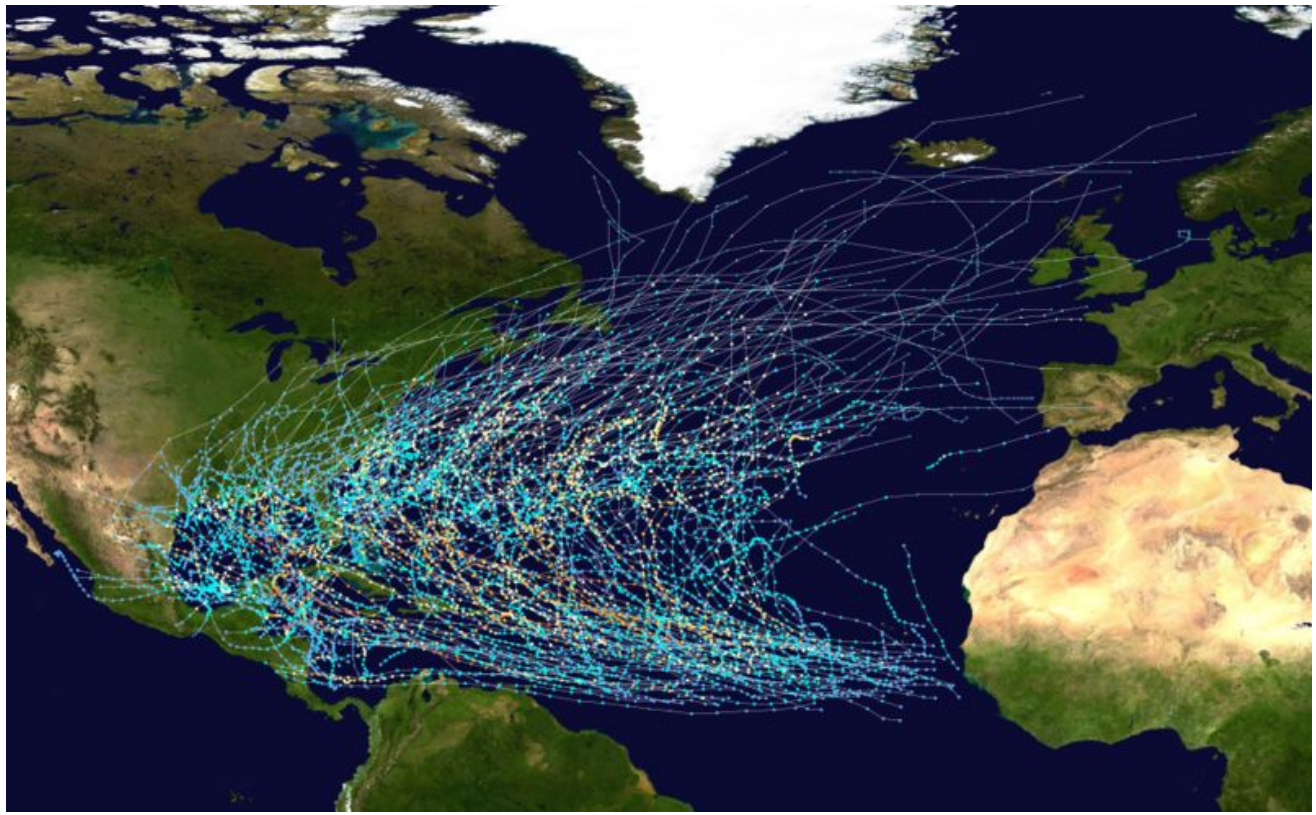
How to Create a Hurricane

The current geology and geography of Africa, the Atlantic Ocean, the Caribbean and the Gulf of Mexico are perfect to create dangerous hurricanes



How to Create a Hurricane

From June to October, hot, dry atmospheric depressions blow to the west off of the Sahara and rapidly pick up evaporating water



How to Create a Hurricane

Atlantic hurricane tracks from 1985 to 2005