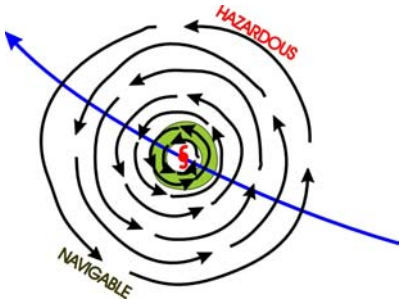
Redfield & Reid Model



Classification

- **Tropical Cyclone:** Nonfrontal, synoptic scalle, cyclonic storm with organized convection that formed over the tropical seas
- **Tropical Depression:** Closed circulation with winds < 17 m s^{-1} (or 35 kt or 39 mph)
- **Tropical Disturbance:** Like a depression, but the winds don't blow completely around the center.
- **Tropical Storm:** Has a closed circulation with winds between 17 m s^{-1} and 33 m s^{-1} (64 kt or 74 mph)

Classification for Winds > 33 m s^{-1} (64 kt or 74 mph)

- **Hurricane:** North Atlantic; NE Pacific, east of 180º, and SE Pacific east of 160º W
- **Typhoon:** NE Pacific, west of 180º
- **Severe Tropical Cyclone:** SW Pacific and SE Indian Ocean, east of 90º E (Australia)
- **Severe Cyclonic Storm:** N Indian Ocean
- **Tropical Cyclone:** SW Indian Ocean, west of 90º E

Saffir-Simpson Scale

Cat	Winds	Effects
One	74-95 mph	No real damage to building structures.
Two	96-110 mph	Some roofing material, door, and window damage to buildings. Considerable damage to vegetation, mobile homes, and piers.
Three	111-130 mph	Some structural damage to small residences and utility buildings with a minor amount of curtainwall failures. Mobile homes are destroyed.
Four	131-155 mph	More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach. Major damage to lower floors of structures near the shore.
Five	> 155 mph	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away.

• Major hurricanes, CAT 3-5, cause 80% of US damage

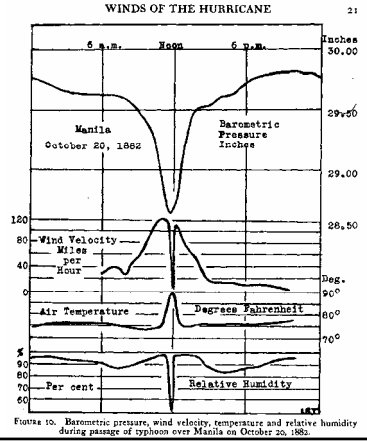
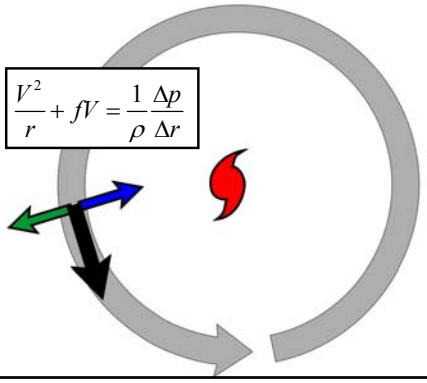


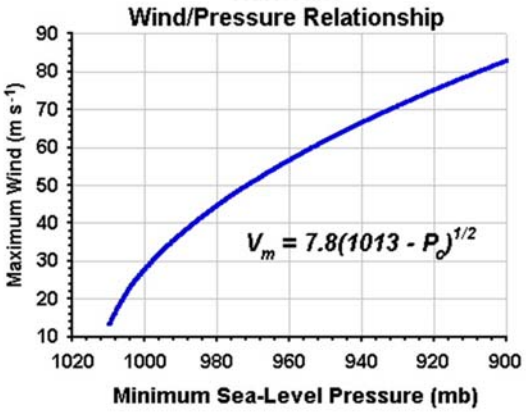
Figure 10. Barometric pressure, wind velocity, temperature and relative humidity during passage of typhoon over Manila on October 20, 1882.

Gradient Balance

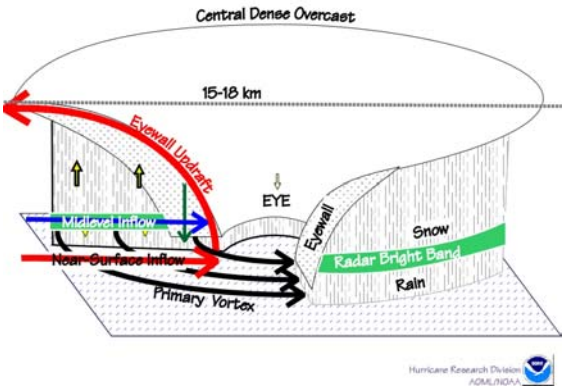
$$\frac{V^2}{r} + fV = \frac{1}{\rho}\frac{\Delta p}{\Delta r}$$

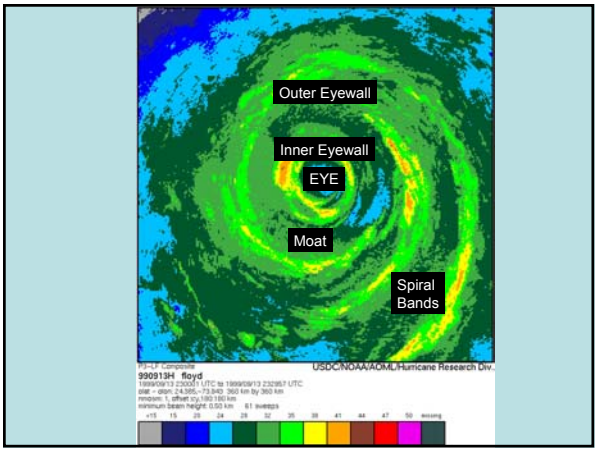


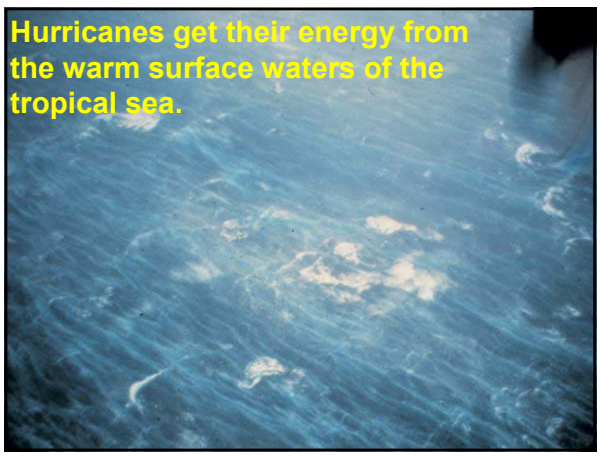
Wind/Pressure Relationship



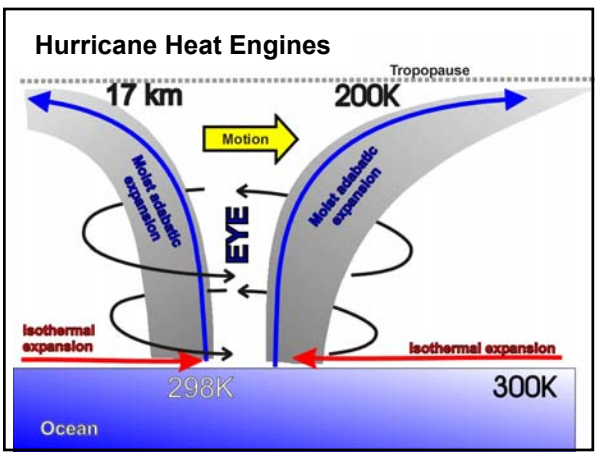
Schematic Hurricane Structure



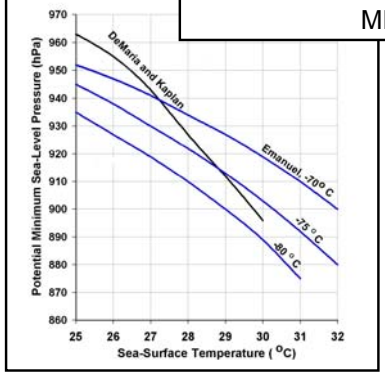




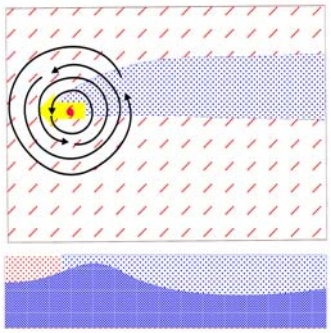
Hurricane Heat Engines



Observational and Theoretical MPI Compared

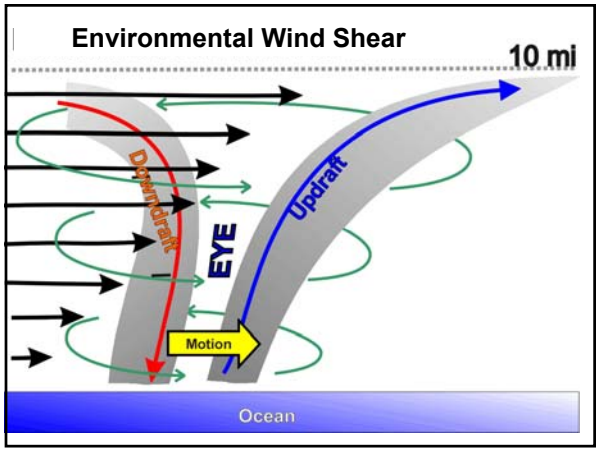


Effect on Ocean Thermal Stratification

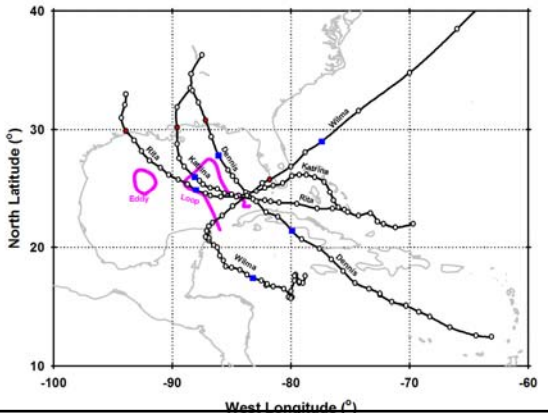


- *Momentum transport causes upwelling .*
- *Wind-Induced turbulence mixes cool water upward.*

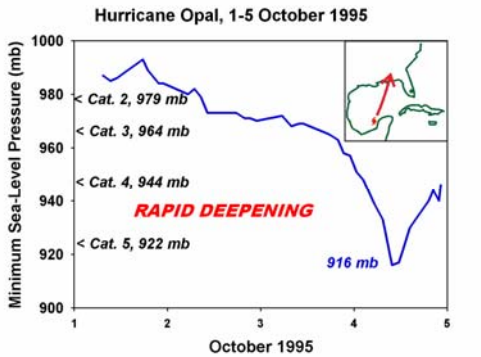
Environmental Wind Shear



Role of the Loop Current

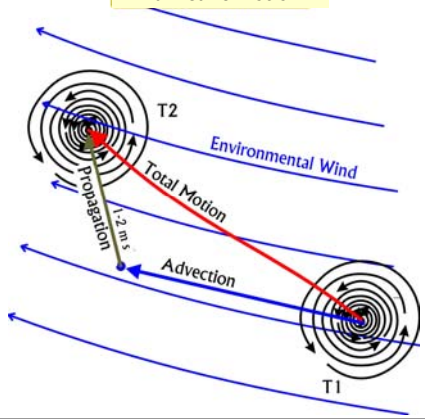


Hurricane Opal, 1-5 October 1995

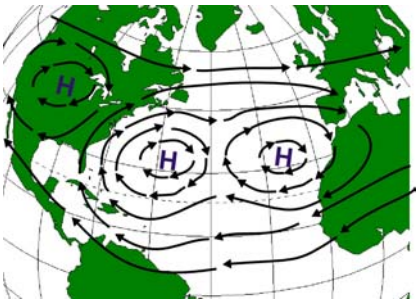


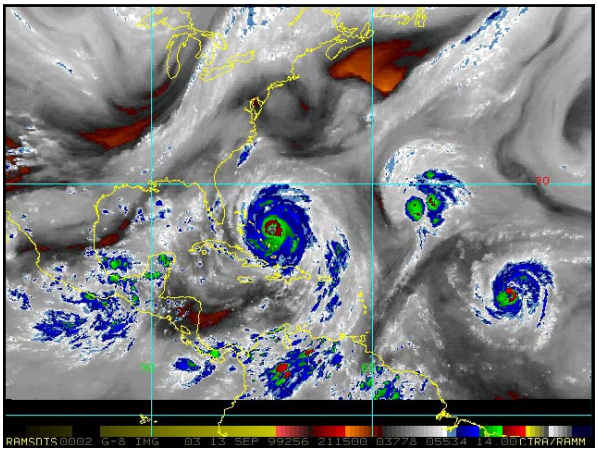
- **Rapid deepening causes most major hurricanes**
- **Time-scale is so short that adequate warnings are difficult**

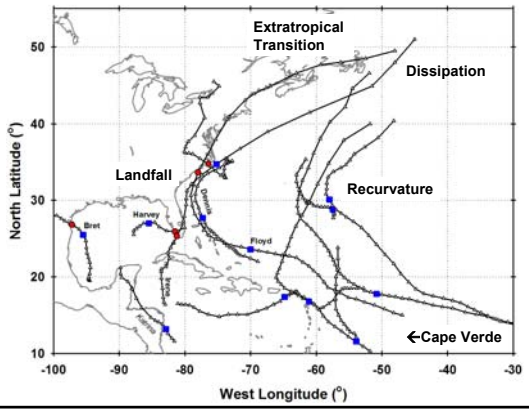
Hurricane Motion



Troughs and Ridges

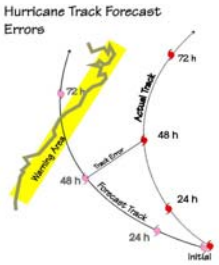


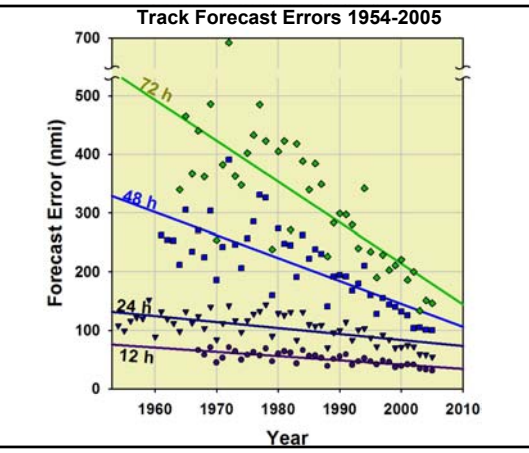




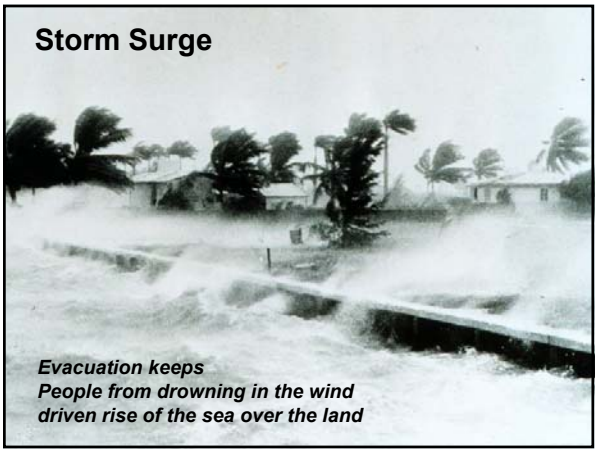
Track Forecasting

- Based upon "guidance" from numerical models
- Evaluated in terms of "vector error" disance from forecast position to actual
- Forecasts cast in terms of:
  - ***Watches***: Hurricane-force winds expeced within 36 h
  - ***Warnings***: Hurricane force winds expected within 24 h
- Trigger evacuation and other preparations under direction of local authorities
- Cost of warnings can be $200-400M





Storm Surge

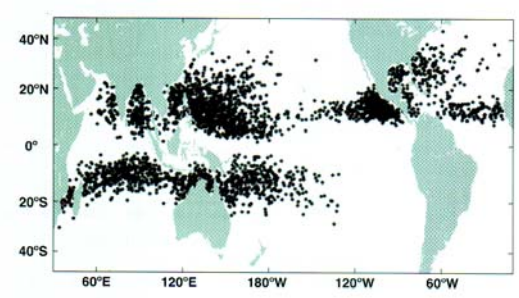


Evacuation keeps People from drowning in the wind driven rise of the sea over the land

Necessary Conditions for Tropical Cyclone Formation

- Ocean warmer than 26°C
- Reasonably humid at 2-5 km altitude (~80% RH… under reexamination)
- Rising saturated air is warmer than its surroundings (conditional instability)
- Weak vertical shear (< 12.5 m s^{-1})
- Pre-existing disturbance
- More than 5° latitude from the Equator

Where Do Hurricanes Form?



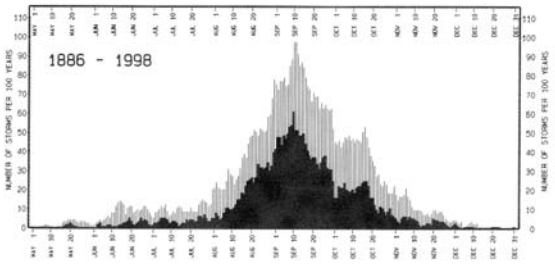
30 years worth

Worldwide Tropical Cyclone Occurrence

Basin	Named	Nonmajor	Major
NW Pacific	26.7	16.9	8.5
S Indian	20.6	10.3	4.3
NE Pacific	16.3	9.0	4.1
N Atlantic	10.6	5.9	2.0
SW Pacific	10.6	4.8	1.9
N Indian	5.4	2.2	0.4

~85 named storms worldwide
~50 > 33 m s^{-1}

Annual Distribution



Tropical Cyclone Tracks 1886-1998

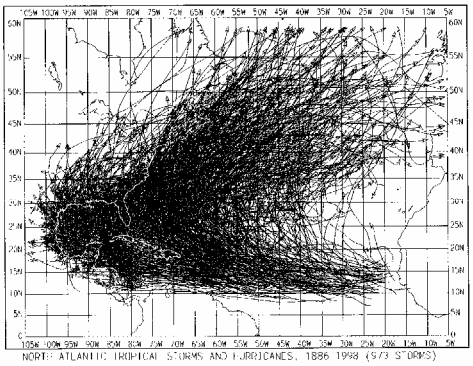
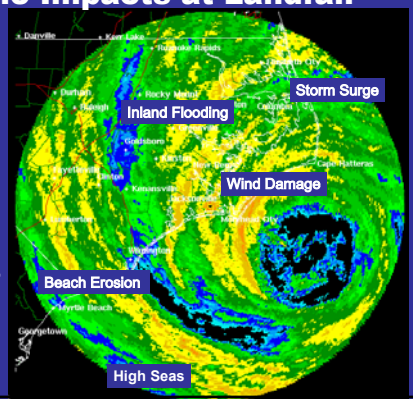


Figure 1. Computer plot showing the tracks of the 573 known North Atlantic tropical cyclones reaching at least tropical storm (see Table 1) intensity over the 113-year period, 1886-1998.

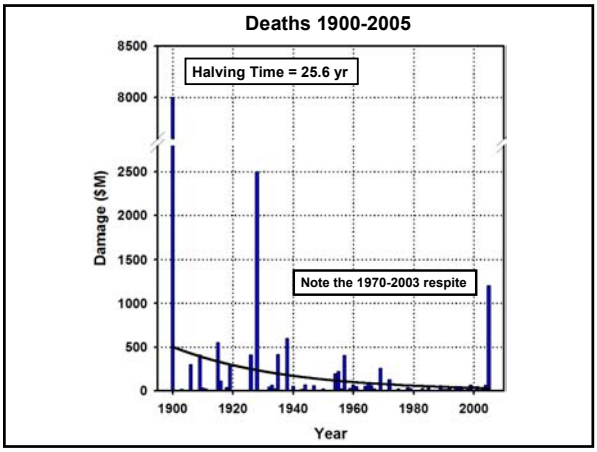
Hurricane Impacts at Landfall

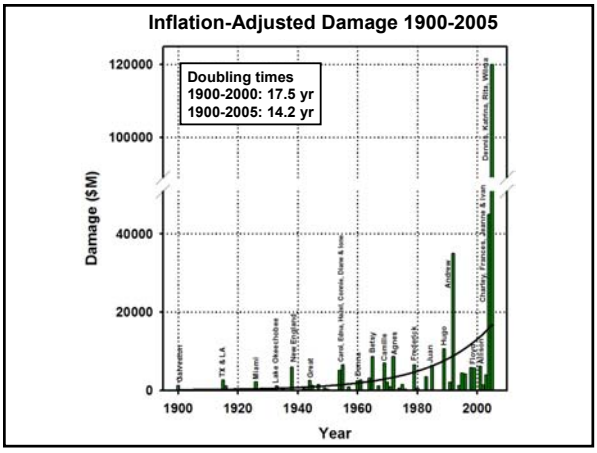


Disruption of Communications, Utilities, Transportation, Schedules & Infrastructure

Drowning in freshwater flooding

caused by torrential hurricane rainfall has accounted for 60%of hurricane related deaths since 1970 Wind accounted for ~17%.





Everybody wants a view like this

Summary

- Be able to draw and explain the Redfield-Ried Model.
- Be able to define: ***Hurricane, Typhoon, Tropical Cyclone (TC), Tropical Storm, Tropical Depression, Tropical Disturbance***
- Understand the ***Saffir Simpson Scale*** in general terms
- Understand the pressure, wind, thermal, and humidity structure of tropical cyclones
- Understand gradient balance in TCs and the ***Pressure-Wind Relation***
- Understand TC's ***Primary Circulation***, ***Secondary Circulation***, and radar reflectivity structure
- Understand the thermodynamics that determine TC ***Maximum Potential Intensity*** and the factors (shear, ocean cooling, encounters with land or cold water) that keep most TCs from reaching their MPI
- Know what ***Rapid Intensification*** is and why it is dangerous
- Know the necessary conditions for TC formation
- Memorize the annual average number of TCs (named storms) wordwide and the number of Hurricanes and named storms in the Atlantic
- Be able to compare and contrast deaths and economic losses due to hurricanes in the US
- For next time **Read Chapter 12**. The final reading assignment will be Chapter 14, The Changing Climate