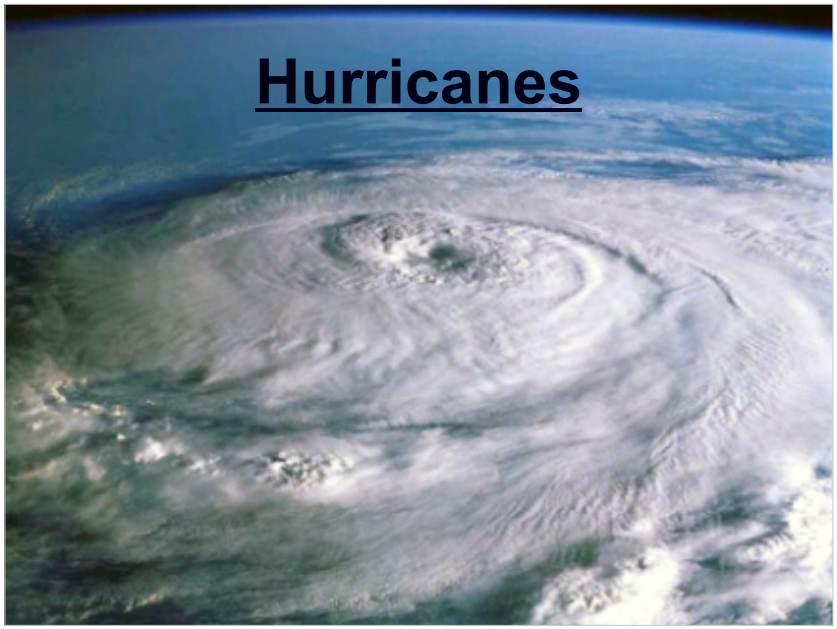
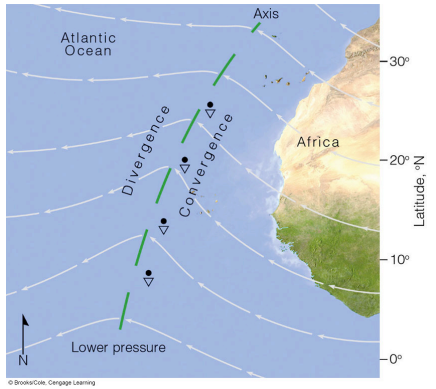


Hurricanes & Easterly Waves

- Winds in the tropics blow from east to west
- Easterly wave (tropical wave): weak trough of low pressure, scale > 2500 km, travels westward at 5-10 m/s (~10-20 mph)
- This wave can intensify into a hurricane



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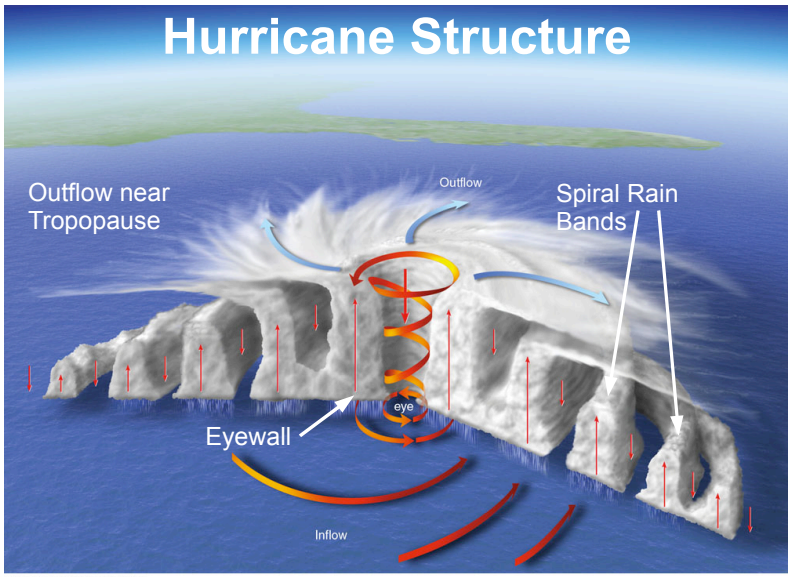
Tropical Storm Categories

- Tropical Cyclone: term for all hurricane type storms that originate in the tropics
  - Hurricane: intense, sustaining winds exceeding 64 kt (form over warm northern Atlantic and eastern Pacific oceans)
  - Typhoon: in the western Pacific
- Stages of a hurricane:
  - Tropical disturbance: slight circulation
  - Tropical depression: winds 20 to 34 kt, relatively strong pressure gradient
  - Tropical storm: winds 35 to 64 kt, very strong pressure gradient
  - Hurricane: winds exceed 64 kt (74 mi/h)

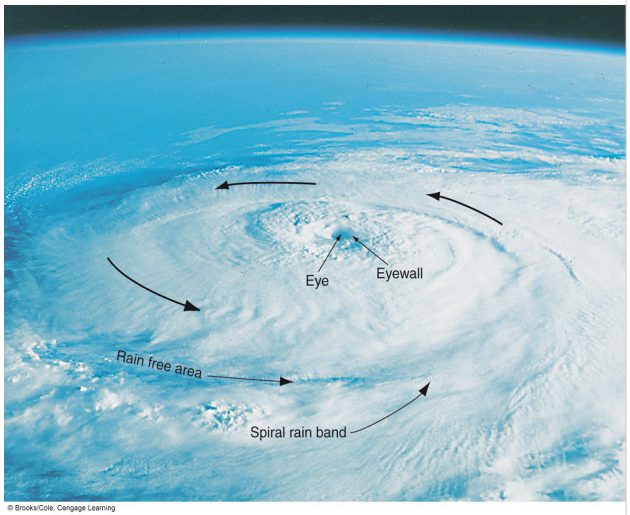
3

Stages of Development

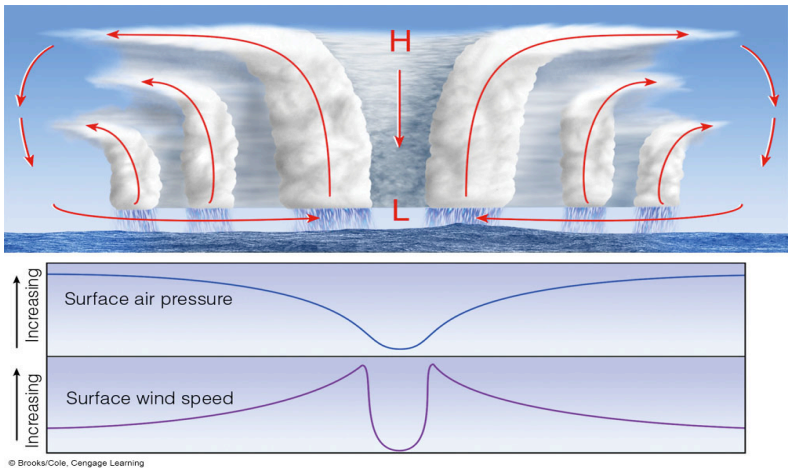


Hurricane Structure

- Eye (calm)
- Eye Wall
- Spiral rain bands
- Rain free areas



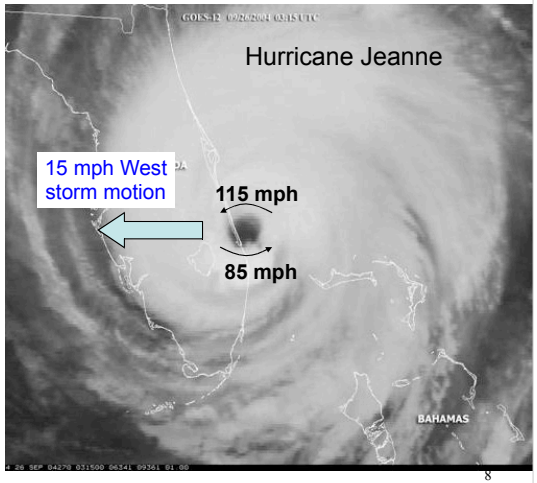
Hurricane Structure



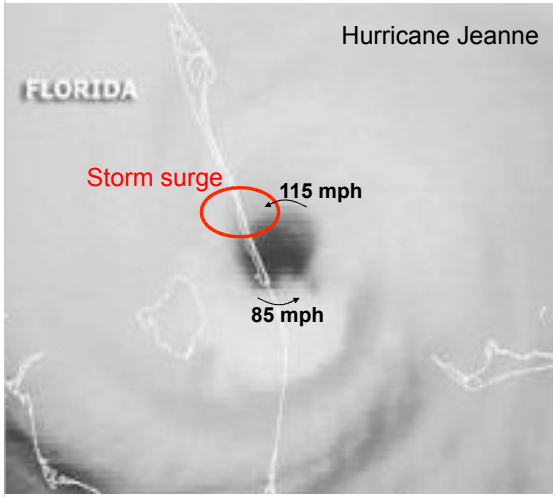
- Surface wind speed is strongest in the eyewall. Pressure is lowest right in the center of the eye.

The Eyewall and Maximum Winds

- Maximum sustained winds are located in the eyewall (also strongest convection)
- For observer on the ground strongest winds are located on the right side of the eyewall with respect to the motion
- Example on the right shows eyewall winds of 100 mph combined with westward motion of 15 mph



The Storm Surge



- Storm surge: region of very high sea level created by the hurricane that can inundate coastal regions
- Strong winds cause convergence of seawater that raises sea level
- Low pressure at hurricane center at sea surface causes sea level to rise a bit

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The Storm Surge
Effects from Hurricane Ike

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Photo from Associated Press, Gilchrist Texas, September 14, 2008

Hurricane Formation

- Light winds, weak to no vertical wind shear
- High humidity through a deep layer of the troposphere
- Warm sea surface temperatures (greater than 80 F = 26.5 C) over a wide area
- Formation between 5 – 20 degrees latitude
  - Coriolis force (zero at equator) required for spin up
- Triggering mechanism required (surface convergence)
- Proposed mechanisms for hurricane formation:
  - Organized convection theory
  - Heat engine theory

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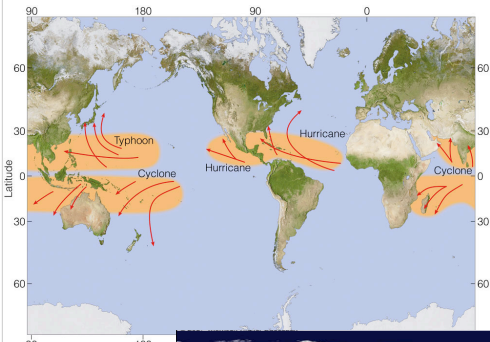
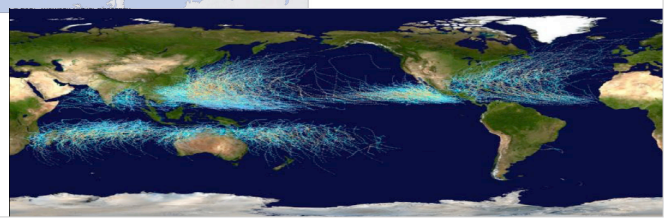
Hurricane Formation & Hurricane Tracks
Climatologically Favored Regions

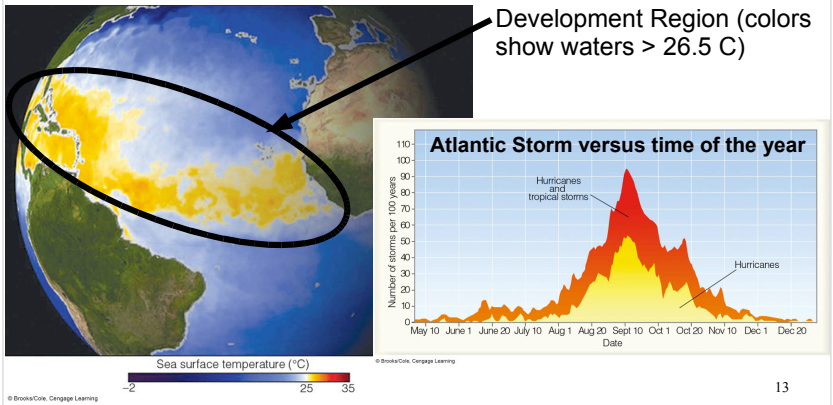


Tropical cyclones are steered in part by the semipermanent subtropical high pressure systems.

Shading represents preferred formation regions.



Climatologically Favored Regions and Seasonal Cycle



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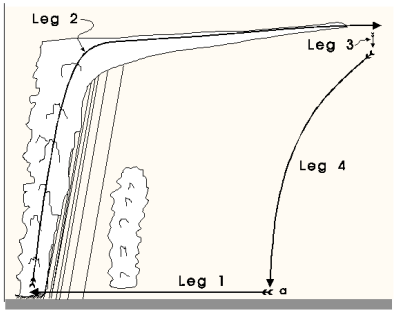
Organized Convection and Heat Engines

Heat Engine: Device that converts thermal to mechanical energy

As documented by Kerry Emanuel, MIT:

- Sea surface acts as a hot reservoir that adds latent heat to the hurricane through evaporation (warmer SSTs support more evaporation), aided by the high hurricane winds (Leg 1).
- Air in the hurricane convects and rises at the moist adiabatic lapse rate (Leg 2)
- The upper troposphere and lower stratosphere acts as the cold reservoir, where the hurricane looses heat through radiative cooling (Leg 3)
- Higher SST → more work goes into lowering storm pressure and strengthening winds than for low SST
- SST sets an upper bound on maximum possible hurricane strength



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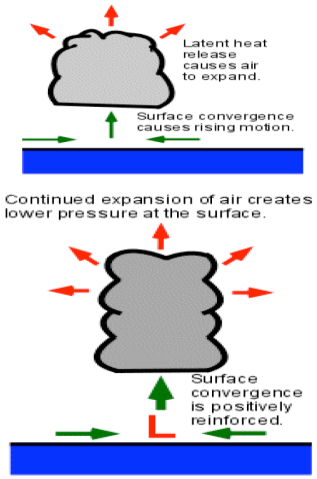
CISK: Organized Convection Theory for Hurricane Formation

- Energy for the hurricane come from latent heat and conditional instability.
- 1: Surface air spiraling towards the center leads to convergence and rising motion.
- 2: Intense latent heating heats the column of air near the center of the storm.
- 3: Lower surface pressure increases the pressure gradient at low levels
- 4: A larger pressure gradient causes more air to converge towards the center, enhancing rising motion and latent heat release.
- This is a **positive feedback loop**, enhancing storm strength



CISK: Organized Convection Theory for Hurricane Formation