Hurricanes

Readings: A&B Ch. 12

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Characteristics of a Hurricane

• Hurricanes:
  ▪ Also called typhoons (in western Pacific) or cyclones (in Australia and Indian Ocean)
  ▪ Form over tropical oceans
  ▪ Have rotary circulation
    ▪ Low pressure system
    ▪ Counter-clockwise in northern hemisphere
  ▪ Have sustained wind speeds > 120 km/h
    ▪ Sustained winds up to 350 km/h
  ▪ Diameter: 100-1500 km across (average 600 km)
  ▪ Pressure at center: ~870-990 mb (average 950 mb)
Structure of Hurricane

- **Eye:** center of storm; ~30km in diameter
  - Lowest pressure
  - Warmest part of storm
  - Air descends gradually, heating up by compression
  - Precipitation ceases
  - ~30 km in diameter
  - When eye is shrinking, hurricane is intensifying

- **Eye wall:** ~10-20 km from center of eye
  - Greatest winds
  - Thickest cloud
  - Heaviest rain
Structure of Hurricane

- Formed from large number of thunderstorms arranged in a pinwheel formation
  - Bands of heavy convection and precipitation separated by areas of weaker uplift and less precipitation
  - Below ~7.5 km: inward spiraling motion around low pressure
  - Above ~7.5 km: cirrus clouds spiral outward around high pressure center

- Hurricanes are “warm-core cyclones”
  - Unlike mid-latitude cyclones, temperature increases toward center of storm
  - Core is kept warm by release of latent heat
Structure of a Hurricane

• In center: centrifugal force is very strong
  ▪ Divergence and sinking air
  ▪ Mostly clear skies in the eye of the hurricane

• Near the eye wall
  ▪ Air rises, cools and releases latent heat of vaporization

• Latent heat is the primary source of energy for the development of a hurricane
  ▪ Requires ocean water > 27°C
  ▪ Ocean temperature influences
    • Length and activity in a hurricane season
    • Location of hurricanes

Development of Hurricane

• *Tropical Disturbance*: a disorganized group of thunderstorms over the eastern part of a tropical ocean basin
  ▪ In the Atlantic basin, most originate as easterly waves – undulations in the trade wind pattern
Development of Hurricane

• *Tropical Disturbances*
  - ~90% die out before becoming organized, as they move over cold Canary current along western Africa
  - ~10% continue westward and organize: pressure decreases and cyclonic rotation develops → *Tropical Depression*

• *Tropical Depression*: classified if the low pressure has at least one closed isobar
  - Wind speeds < 60 km/h

• *Tropical Storm*: develops if a tropical depression intensifies
  - Wind speeds > 60 km/h
  - At this point, the system is named
  - ~80-100 tropical storms per year in world oceans
  - ~10 tropical storms per year in the Atlantic Ocean

• *Hurricane*: develops from tropical storm
  - Wind speeds > 120 km/h
  - ~40 hurricanes per year in the world oceans
  - ~6 hurricanes per year in the Atlantic
Influences on Hurricane Development

• Conditions necessary for hurricane development
  ▪ Ocean surface must be > 27°C, to provide enough latent heat
    • No hurricanes form pole-ward of 20°
  ▪ Coriolis force must be sufficiently strong to prevent low pressure center from filling
    • No hurricanes form equator-ward of 5°
  ▪ Unstable conditions through entire depth of troposphere
    • No hurricanes form in E. Atlantic over cold current

• Hurricanes develop between 5-20° (N/S) over westernmost portion of warm oceans

Hurricane Path

• Hurricanes and tropical storms are highly erratic in movement
  ▪ Changing speed or direction, occasionally back-tracking

• Hurricane path is influenced by
  ▪ Hadley cell: easterly trade winds in tropics
  ▪ Westerly winds in mid-latitudes
  ▪ Warm ocean currents
Hurricane Dissipation

• A hurricane will dissipate:
  ▪ When it moves over land
    • Loses source of moisture and latent heat
    • Rougher surface causes a reduction in wind speed → pressure gradient force dominates
      ▪ Low pressure center fills
  ▪ When it moves further pole-ward
    • Cooler sea surface temperatures
      ▪ Most hurricanes weaken as they track northwards along the east coast of the U.S.
  ▪ When it reaches a location where flow aloft is unfavorable (counteracting hurricane movement)

Hurricane Destruction

• High wind speeds:
  ▪ by definition > 120 km/h
• Heavy rain and flooding
  ▪ Up to 10 m/day of precipitation from eye wall
  ▪ Up to 10 in./day at any particular location
• Tornadoes
  ▪ Most often in right forward quadrant
• Storm surges – high water level due to:
  ▪ Piling up of water dragged by heavy winds
  ▪ Low pressure
• Debris carried by water contributes to damage
Hurricane Destruction

- Hurricane winds and storm surges are most intense on the right-hand side of the storm, relative to direction of travel

Detection and Tracking of Hurricanes

- National Hurricane Center (NHC, Miami FL)
  - Track hurricanes and tropical storms in the Atlantic and eastern Pacific
  - Use:
    - Flights into hurricanes
    - Satellite imagery
    - On-ground instrument packages
    - Computer models
  - Hurricanes are very erratic; prediction is difficult
  - Issue:
    - Hurricane Watch: when landfall is predicted in more than 24 hours
    - Hurricane Warning: when landfall is predicted within 24 hours
Saffir-Simpson Hurricane Intensity Scale

- Saffir-Simpson scale classifies hurricanes into five categories
  - Based on highest wind speed sustained for 1 minute or longer

<table>
<thead>
<tr>
<th>Category</th>
<th>Wind speed (km/h)</th>
<th>Pressure (mb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>120-155</td>
<td>≥ 980</td>
</tr>
<tr>
<td>Category 2</td>
<td>155-178</td>
<td>965-979</td>
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<tr>
<td>Category 3</td>
<td>179-210</td>
<td>945-964</td>
</tr>
<tr>
<td>Category 4</td>
<td>210-250</td>
<td>920-944</td>
</tr>
<tr>
<td>Category 5</td>
<td>&gt;250</td>
<td>&lt;920</td>
</tr>
</tbody>
</table>

- Only six Category 5 hurricanes have occurred in the western Atlantic or Gulf of Mexico, since 1969