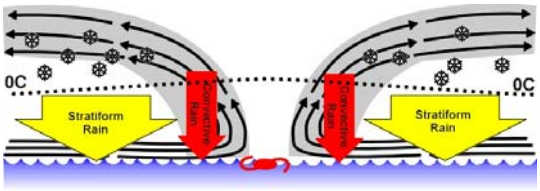
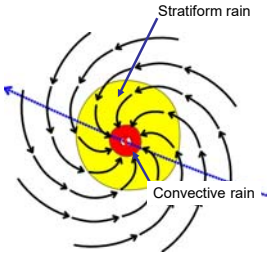
Stratiform and Convective Rain



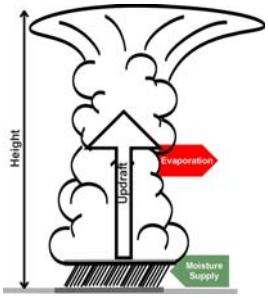
Modified Redfield-Reid Paradigm



- Circular vortex
- Lasts for many orbital periods of the swirling wind around the center
- Maximum wind much faster than motion
- Air spirals inward because of friction and updrafts forced by heating
- Updrafts in convective clouds lift the air from the surface to > 15 km
- Producing copious rainfall
- Rainfall, like the wind, moves as a coherent, relatively slowly changing pattern relative to the translating center

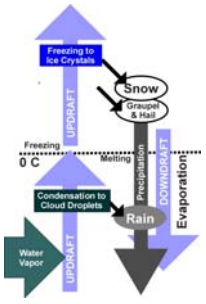
Rain Rate Depends Upon…

- Moisture Supply—Low-level humidity
- Evaporation—Middle level humidity & cloud size
- Updraft strength→ rate of condensation
- Cloud height→ Amount of water condensed
- Not independent

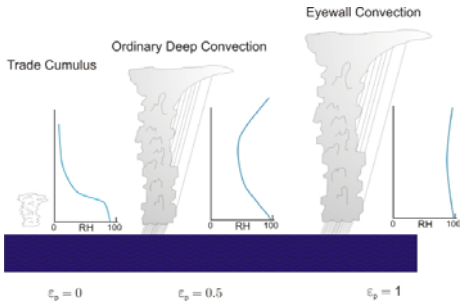


What Happens in a Cloud?

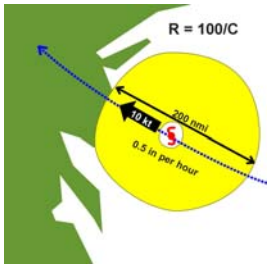
- Updraft leads to cooling and condensation.
- Forms cloud droplets, 10-50 μm in diameter.
- Cloud droplets collide and coalesce to form rain
- Are also carried upward to temperatures < 0ºC
- They eventually freeze
- Ice grows faster than supercooled liquid H_2O
- Forms snow, graupel, and hail
- Which melts to form rain when the fall below 0ºC level
- Precipitation loading and evaporative cooling force downdrafts.



Precipitation Efficiency

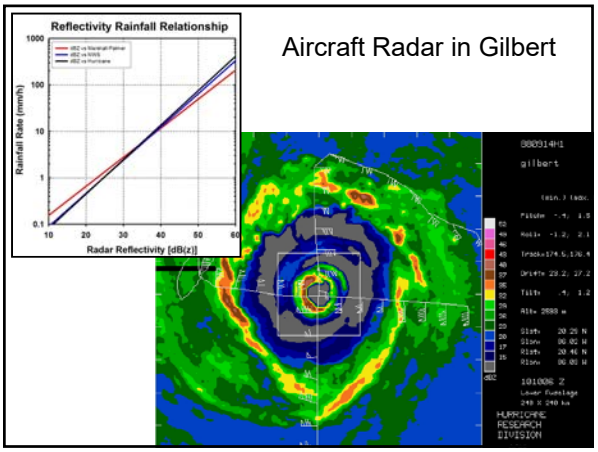


Kraft TC Rainfall Approximation



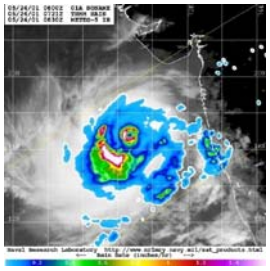
- Based upon experience
- Predicts STORM-TOTAL rainfall
- Rationale:
  - Size doesn't change much
  - Neither does rainfall rate
  - Only thing that changes a lot is speed of motion
- Example: 10 kt speed → 10 in of rainfall
- Doesn't always work well, e.g. 1938 New England Hurricane
- Rainfall CLIPER has a cross-track statistical distribution
- Could also include dimensions and rain rates based upon satellite or radar

Aircraft Radar in Gilbert



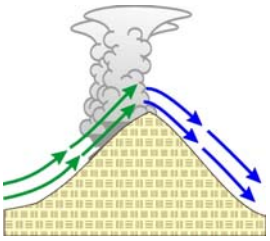
TRMM

- Tropical Rainfall Measuring Mission
- Designed to measure the convective heating of the topical atmosphere
- Instruments
  - Precipitation radar (dual wavelength 2.2 & 0.8 cm)
  - Microwave imager
  - VIS/Ir Scanner
  - Radiant energy sensor
  - Lightning detector
- Used to estimate rainfall as a weather element as well



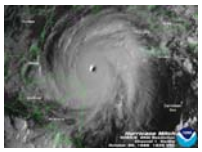
Orographic Rainfall

- Strong winds encounter an upward slope
- Rising motion initiates convective updraft
- Causing very heavy rain
- Rapid runoff → flash floods
- Mudslides on unstable slopes

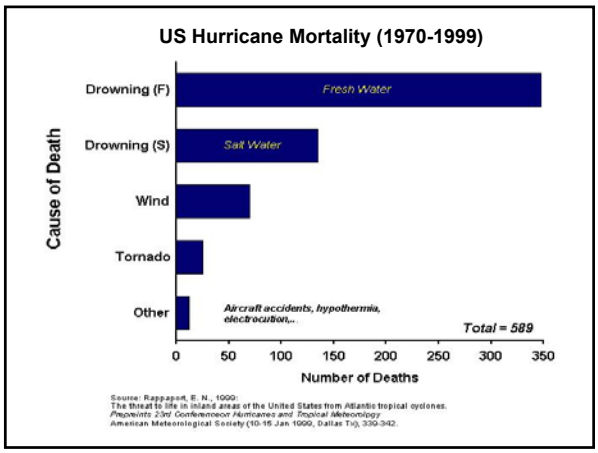


Hurricane Mitch

- **Late season storm (November 1998)**
- **Intensified to CAT 5**
- **Drifted generally westward into the Gulf of Honduras**
- **Devastated the Islas de la Bahia and Roatan Is.**
- **Sank Windjammer Cruise ship *Fantome***
- **Made landfall as a Cat 1**
- **Lingered and weakened over Central America for 3 days**
- **Dropped 90 cm of rain over a wide area.**
- **Killed nearly 11,000, mostly in Nicaragua and Honduras**
- **Reformed over the Bay of Campeche and eventually passed over Florida as a TS.**



Inundación en Guatemala by Diego Isaias Hernadez Mendez, 2001



Summary

- Redfield-Reid applied to rainfall: Pattern moves with storm center, but does not change rapidly
  - Low-level convergence feeds moisture into the storm
  - Rising motion causes condensation
  - Convective and stratiform rain
- Cloud processes
  - Warm rain and role of ice,
  - Conversion of suspended cloud water into precipitation
- TC precipitation efficiency enhanced by low evaporation in TCs
- Kraft's rule R (in) = 100/C(kt)
- Radar: Microwave beams reflected by raindrops, not snow or cloud
  - Z-R relationship
  - Airborne radar and spaceborne radar (TRMM)
- Orographic (upslope) rainfall in landfalling storms
- Hurricane Mitch (1998) drowned ~11,000 in Guatemala and Honduras after weakening from CAT 5 to CAT 1at landfall, TS inland
- Freshwater flooding caused 60% of US hurricane-related deaths 1970-2004 (pre Katrina)

For next time
SW: 125-141, 142-156