

- Tropical cyclone background
- Saffir-Simpson scale
- Overview of structure



*Goal: Understand the classification and basic structure of tropical cyclones*

# Defintion of a tropical cyclone

- A tropical cyclone is a tropically-originating, warm core, nonfrontal system that develops over the ocean and exhibits an organized surface circulation.
- Generically, the term tropical cyclone is applied to systems with peak wind speeds of at least  $17 \text{ ms}^{-1}$ , with peak defined regionally as either 1-minute mean, 10-minute mean, or gust winds.
- The most intense tropical cyclones are referred to by different names regionally:
  - *Hurricane [Atlantic and Eastern Pacific]*
  - *Typhoon [Eastern Asia]*
  - *Severe Tropical Cyclone [India/Australia]*
  - Also *willy-willy [Australia]*, *bagyo/baguio [Philippines]*

# Etymology

- **Cyclone**
  - From a Greek word translating to “coiled like a snake” first used in the mid 19th-century
- **Hurricane**
  - Taino in Caribbean: *jurac án*
  - Maya: *huracan* or *hurakan*
- **Typhoon**
  - Entered the English language in the late 16th century
  - Chinese: *Tai Feng* or “Tai wind” but earlier as *Chu Feng*
  - Greek mythology: *Typhon* [oldest known usage]
  - Arabic: *Tufan*



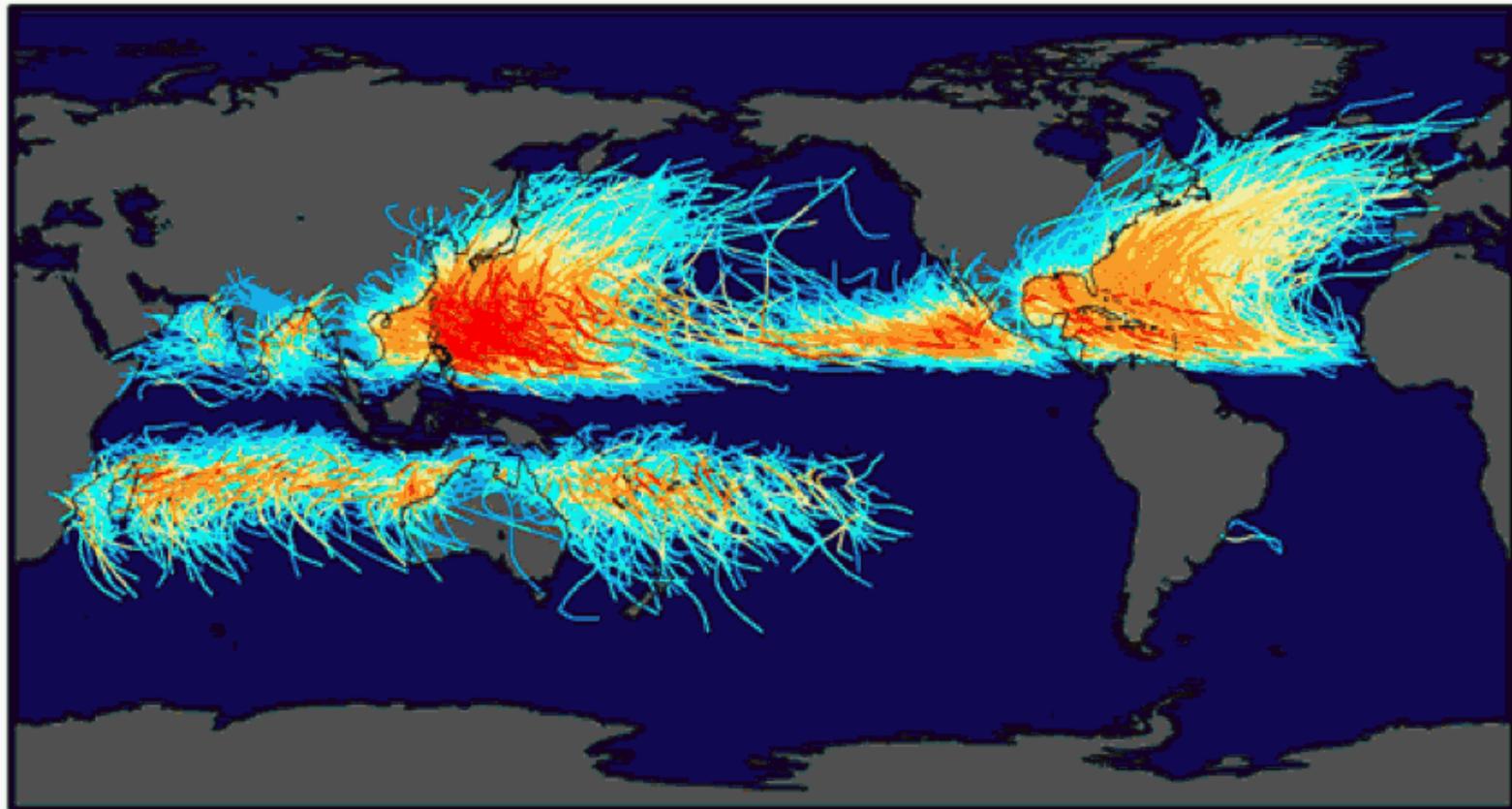
# A sampling of historical events

- 1274: Kublai Khan's first invasion of Japan thwarted by a typhoon
- 1559: Spain's first attempt to colonize Florida failed as a hurricane destroys ships at Pensacola
- 1609: English ships heading toward Jamestown Virginia wrecked at Bermuda by a hurricane, where colonists establish the first European settlement; accounts became the basis of the *Tempest* by William Shakespeare
- 1722: New Orleans destroyed by a major hurricane
- 1900: Hurricane of 1900 devastates Galveston, killing ~8,000 and leaving 30,000 homeless
- 1938: The New England Hurricane of 1938, aka the Long Island Express, struck the northeast US as a category 3, resulting in 682 deaths
- 1970: Great Bhola cyclone in Bangladesh killed 500,000



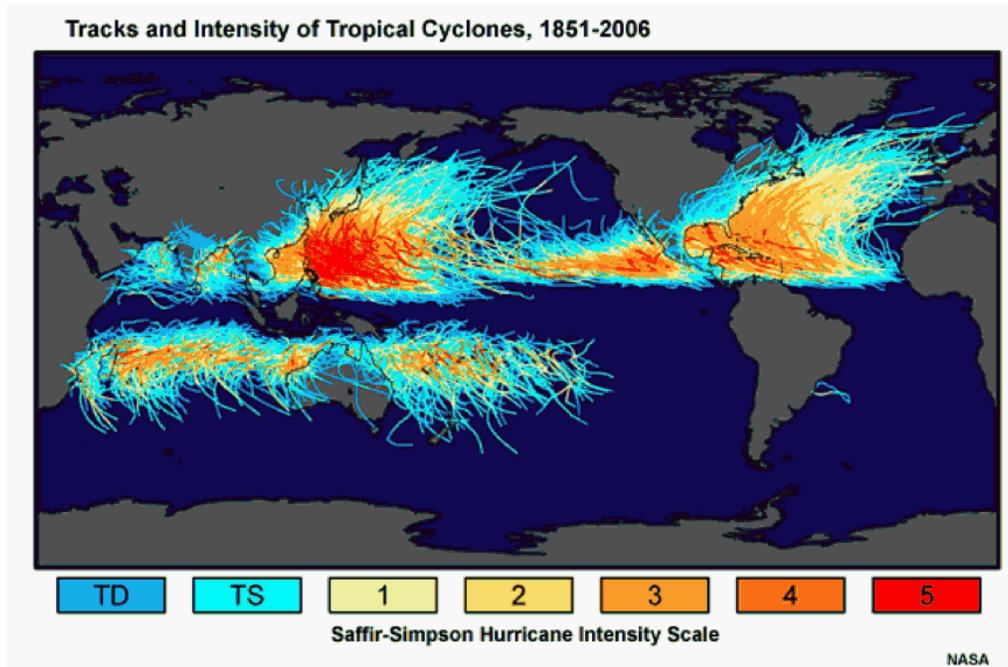
# Distribution of tropical cyclone tracks and intensity

Tracks and Intensity of Tropical Cyclones, 1851-2006



Saffir-Simpson Hurricane Intensity Scale

# General observations\*



- Tropical cyclones do not occur close to (within  $\sim 5^\circ$  of) the equator
- Northern Hemisphere activity is more frequent and of higher intensity compared to the Southern Hemisphere
- Longitudinal asymmetry is apparent, especially in the Southern Hemisphere where activity is absent over the South Atlantic and Southeast Pacific
- The western North Pacific is the most active region with the most intense storms
- Northern Hemisphere cyclones tend to extend farther poleward than Southern Hemisphere cyclones

***\*An important caveat is that the North Atlantic and Pacific basins have been better sampled historically.***

# Steps in hurricane development

- Tropical disturbance: cluster of thunderstorms with organized circulation
- Tropical depression: winds between 10-17  $\text{ms}^{-1}$  (20-34 knots); system is numbered
- Tropical storm: winds between 17-33  $\text{ms}^{-1}$  (35-64 knots); system is named\*
- Hurricane: winds greater than 33  $\text{ms}^{-1}$  (64 knots)

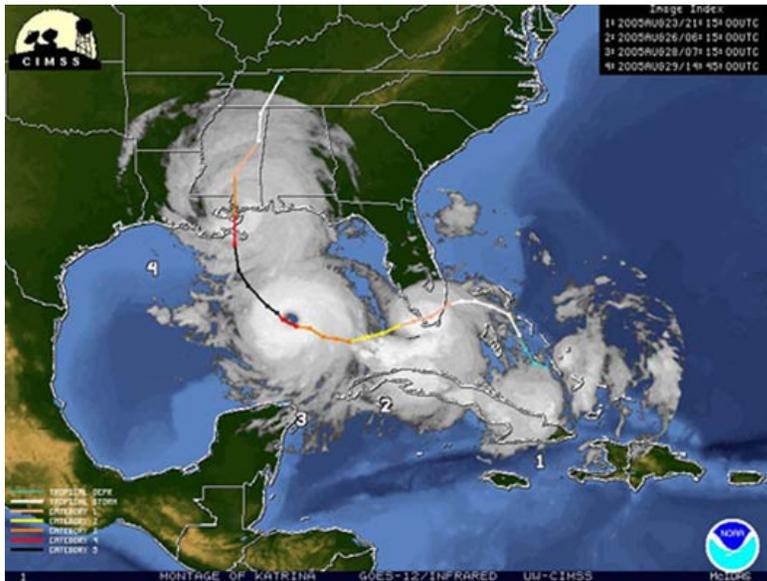
\*Individual storms were first named by an Australian meteorologist using Greek letters and names of disliked politicians. Today's naming convention is more standardized: male and female names for different regions affected.

# Saffir-Simpson Scale

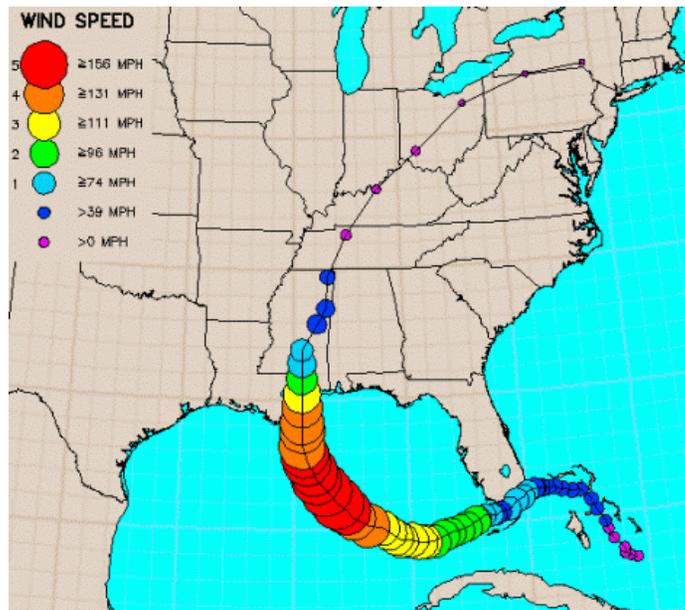
Saffir-Simpson Category	Maximum Sustained Wind Speed ( $V_{MAX}$ ; 1-minute average) <sup>b</sup>			Minimum Central Pressure ( $p_{MIN}$ )
	$m s^{-1}$	$km h^{-1}$	mph	
1	33-42	119-153	74-95	> 980
2	43-49	154-177	96-110	979-965
3	50-58	178-209	111-130	964-945
4	59-69	210-249	131-155	944-920
5	70+	250+	156+	< 920

- Scale developed by Herb Saffir and Robert Simpson in the late 1960s to relate observed damage to peak surface winds and minimum surface pressure
- Storms at or above category 3 are considered major hurricanes

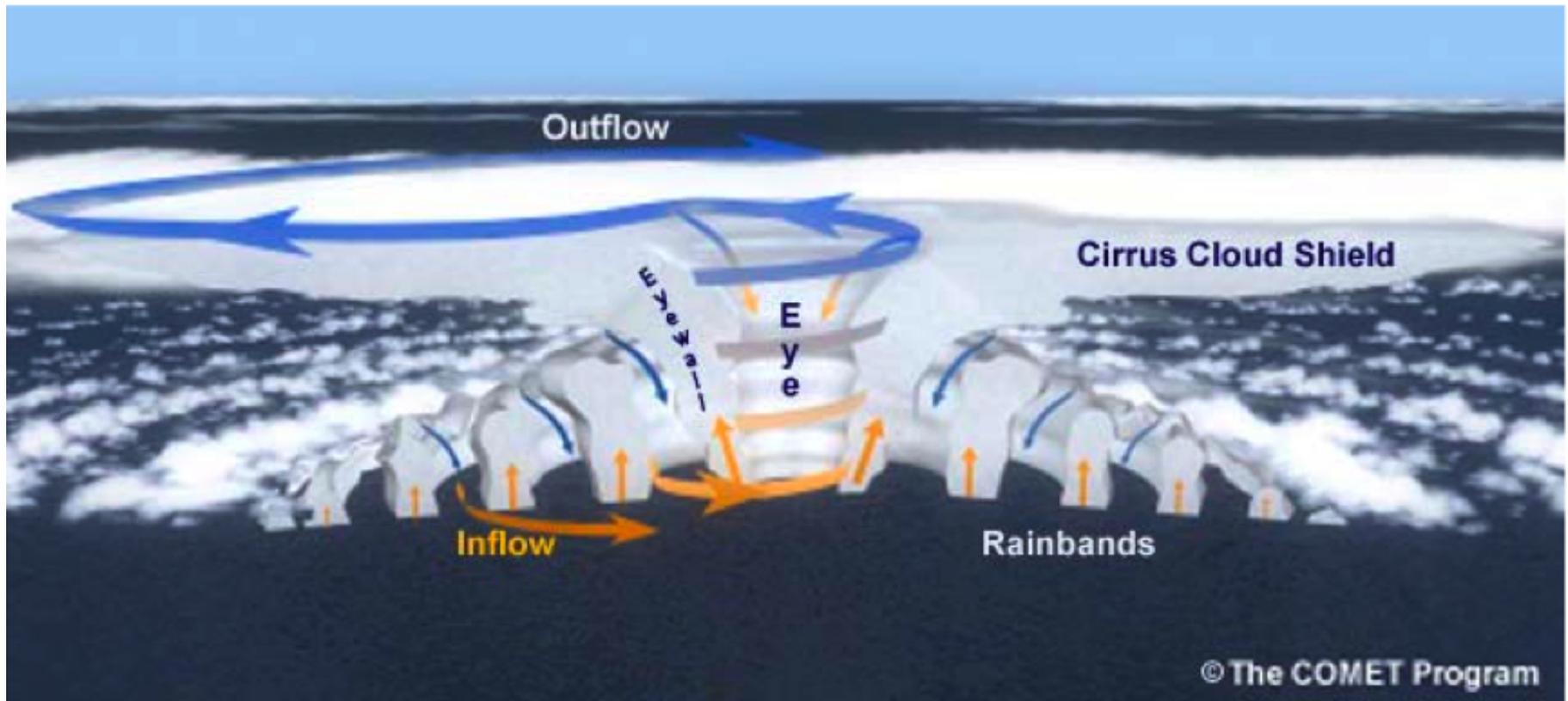
# Katrina's day-to-day evolution



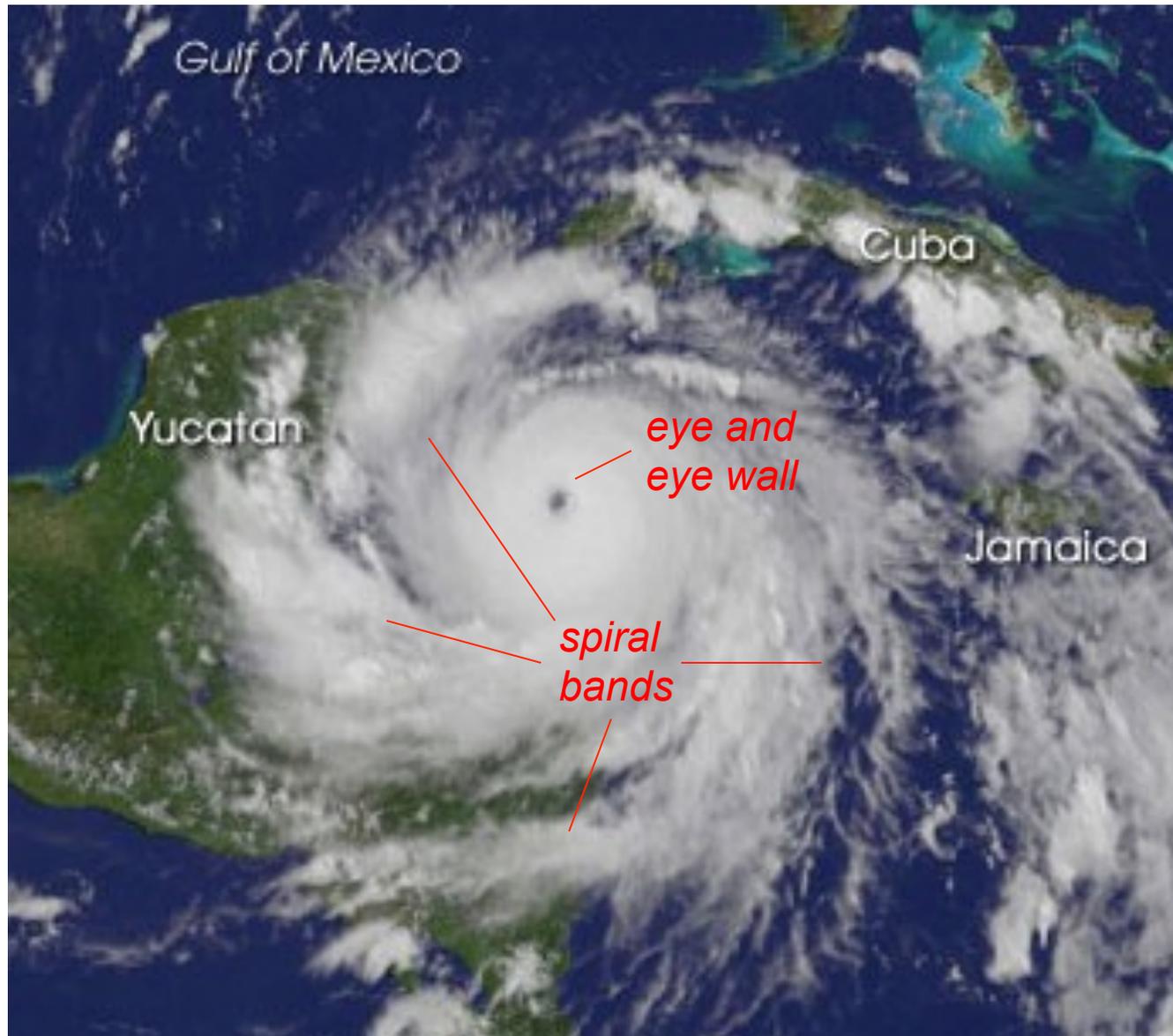
- 08/23/05: TD12 over SE Bahamas [interaction of tropical wave with remnants of TD10]
- 08/24: Upgraded to TS and named Katrina
- 08/25: Upgraded to H 2 hours before landfall on the east coast of Florida
- 08/25-08/26: Weakening over land followed by restrengthening upon entry into the southeastern Gulf of Mexico
- 08/27: Category 3 (major hurricane)
- 08/28: Category 5
- 08/29: Second landfall (Cat 3) near Buras-Triumph, LA; hurricane force winds extending out 190 km; maintained hurricane strength 240 km inland
- 08/31 last distinguishable presentation near Great Lakes on 08/31 when absorbed by a passing midlatitude front



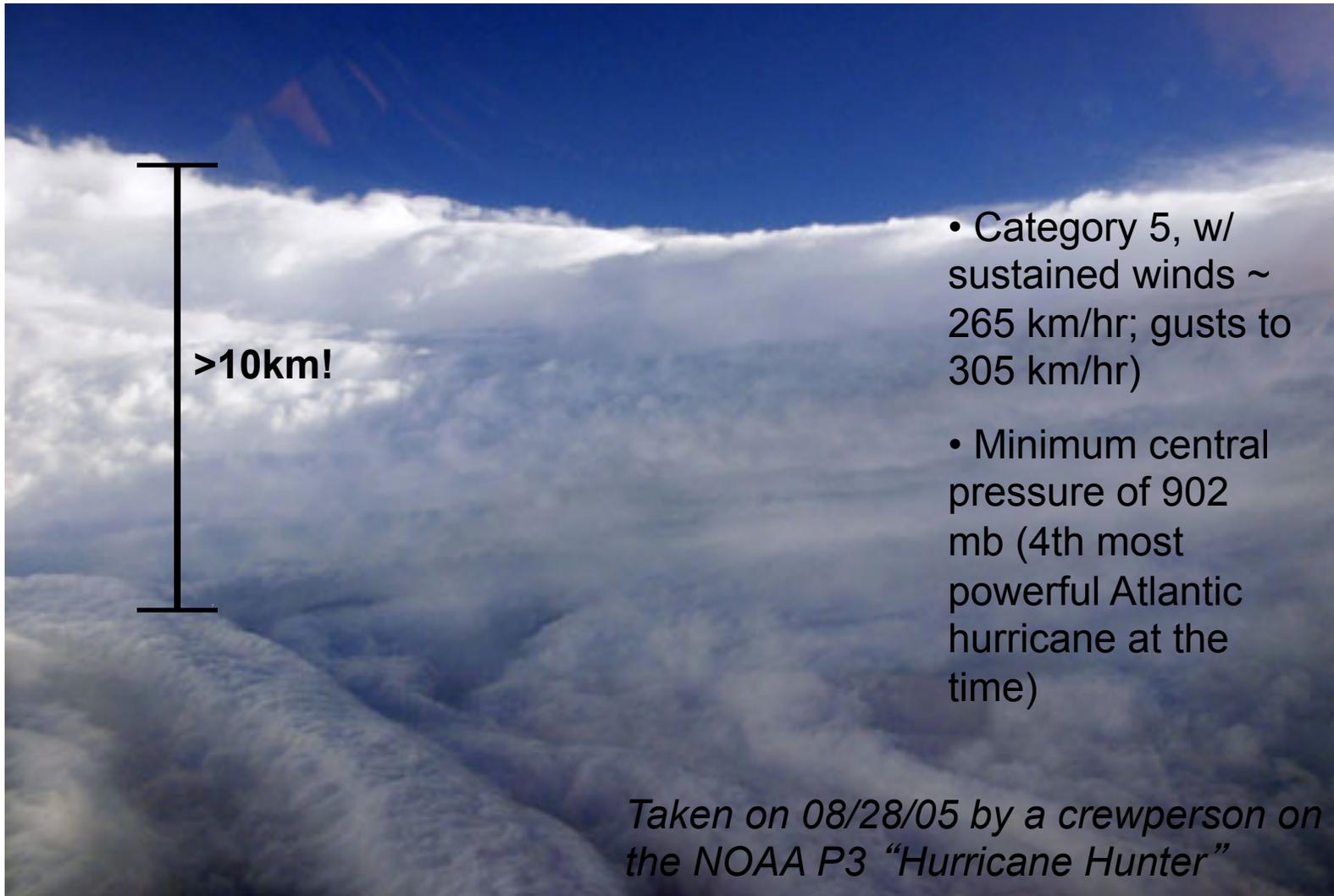
# Key anatomical features



# Hurricane Dean on 08/20/07



# Inside Katrina's eye!

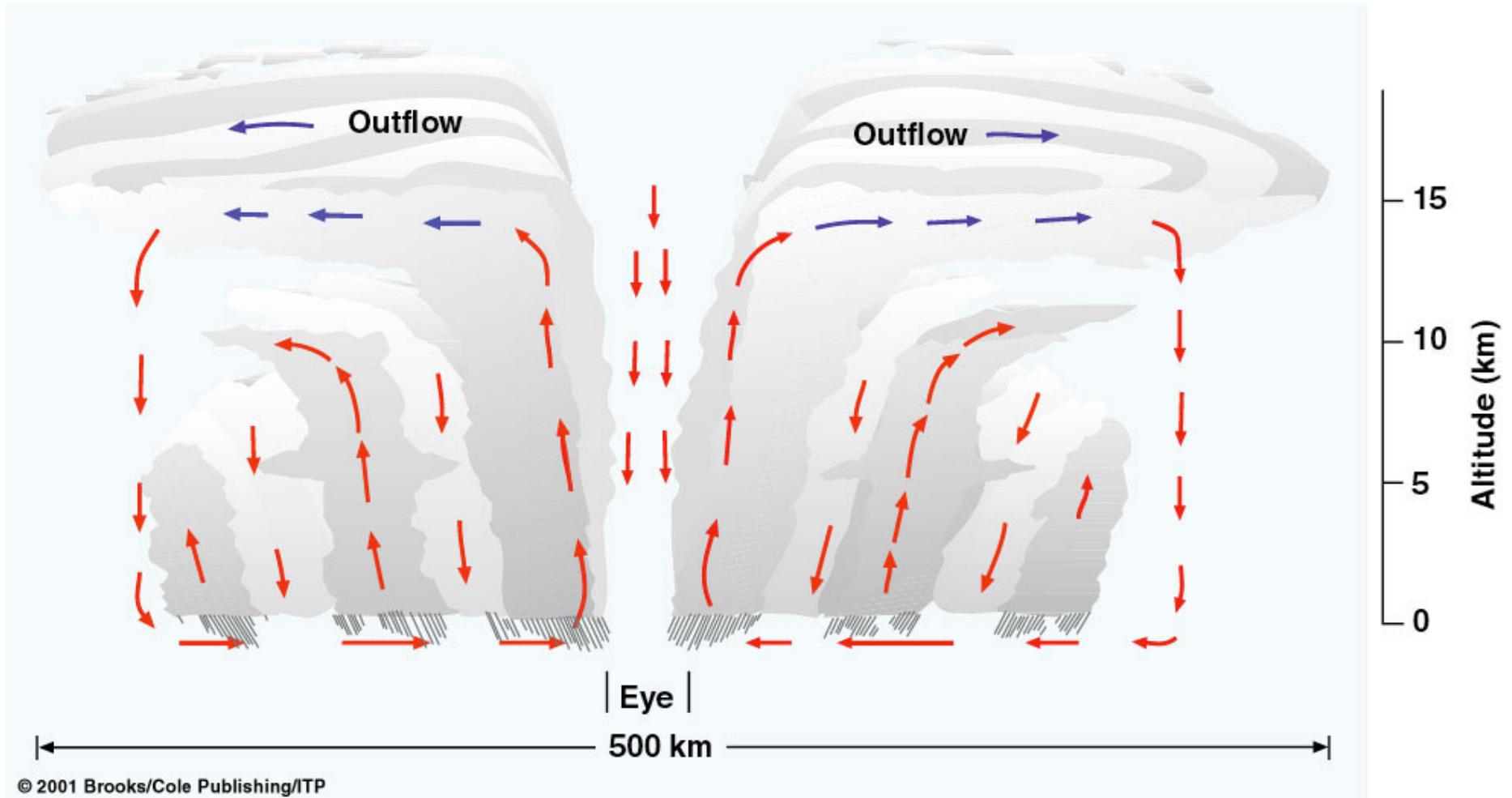


>10km!

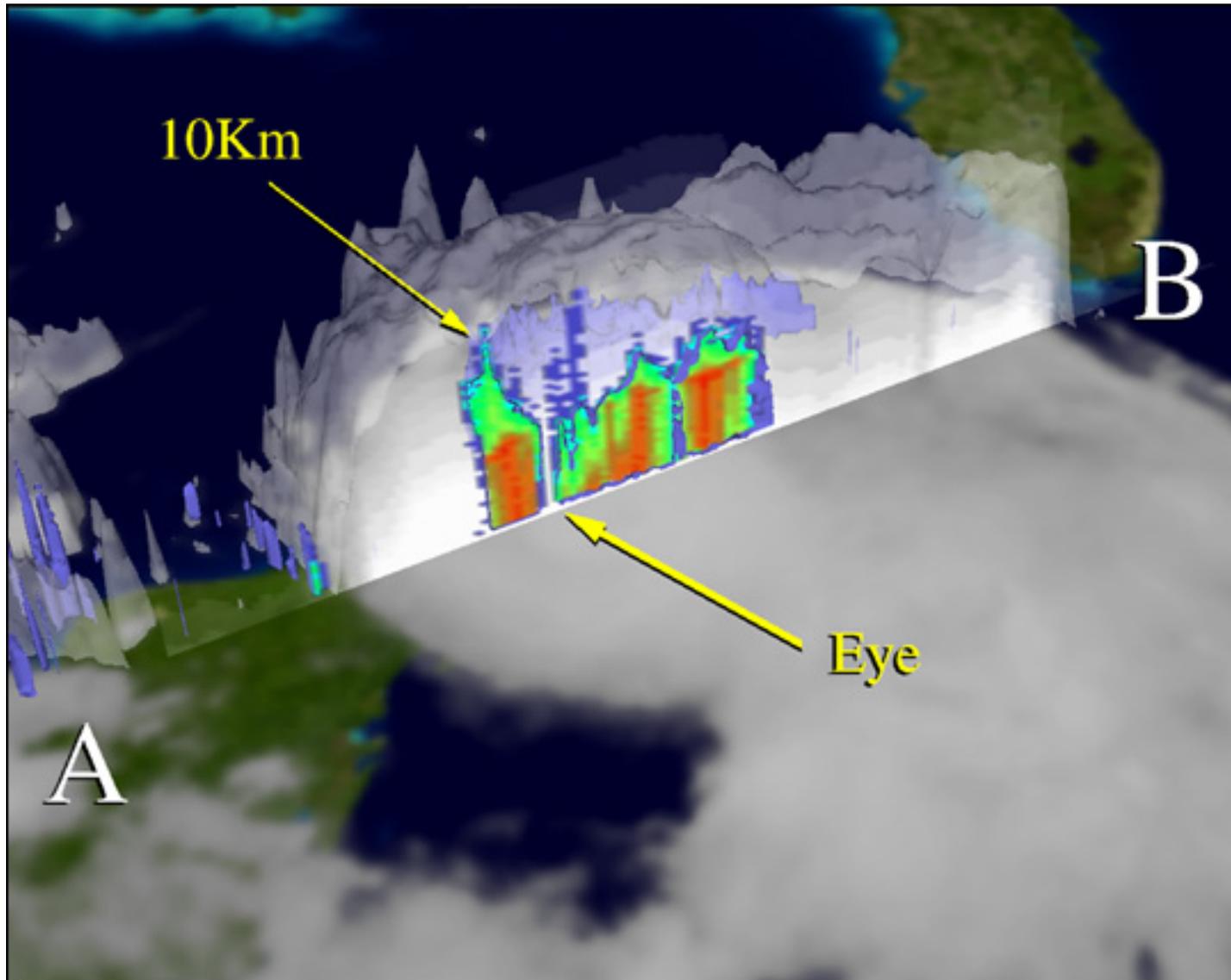
- Category 5, w/ sustained winds ~ 265 km/hr; gusts to 305 km/hr)
- Minimum central pressure of 902 mb (4th most powerful Atlantic hurricane at the time)

*Taken on 08/28/05 by a crewperson on the NOAA P3 "Hurricane Hunter"*

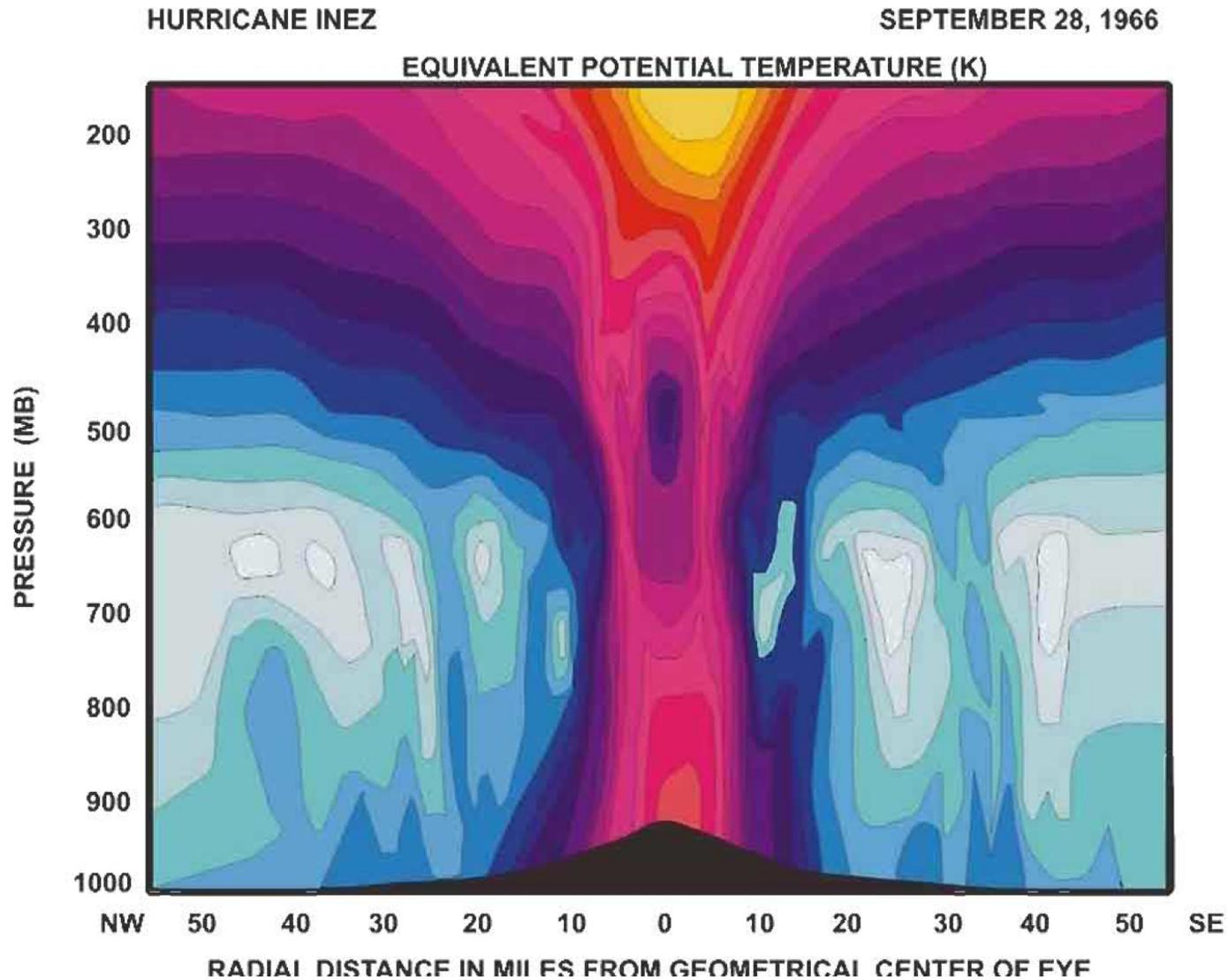
# Hurricane cross-section



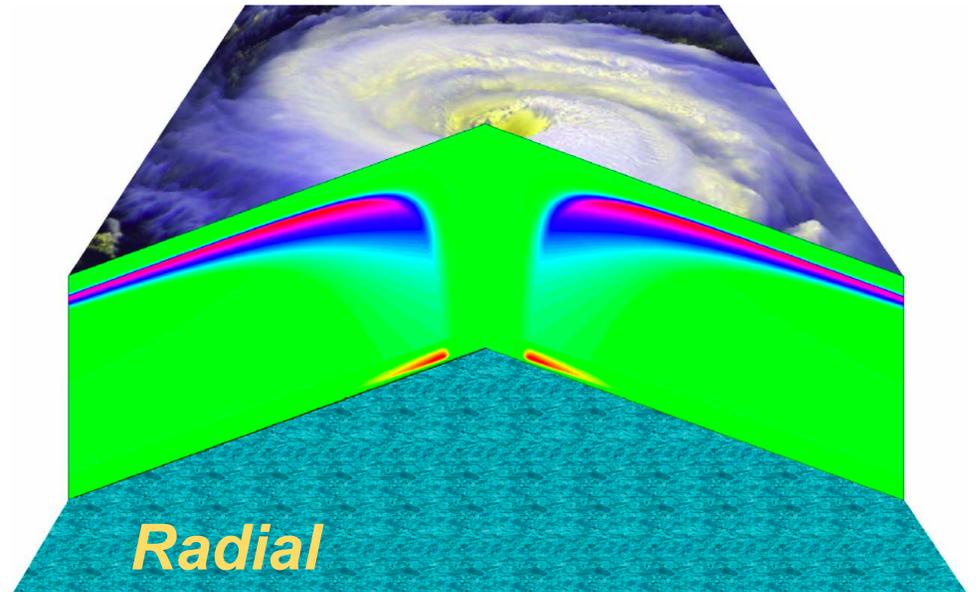
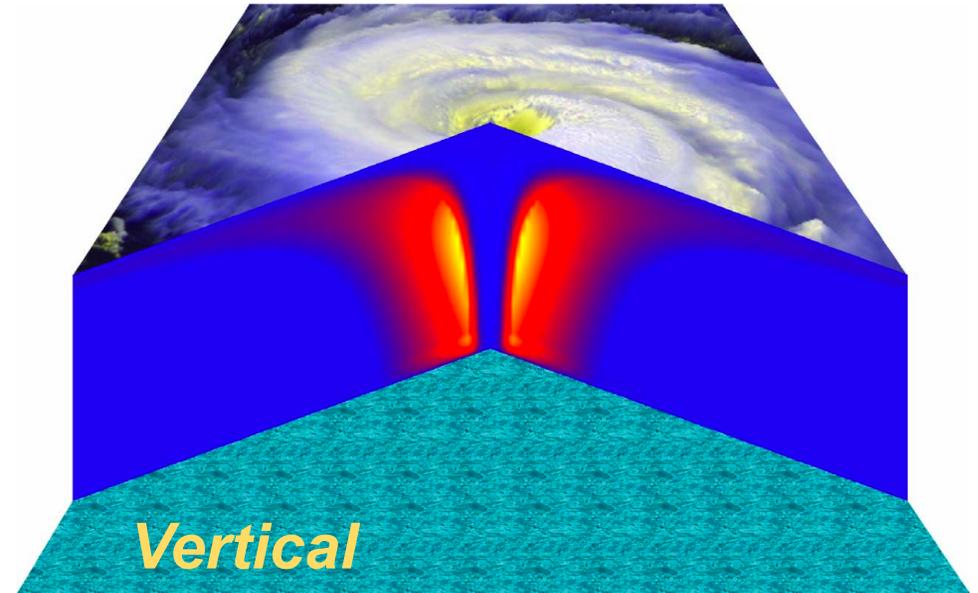
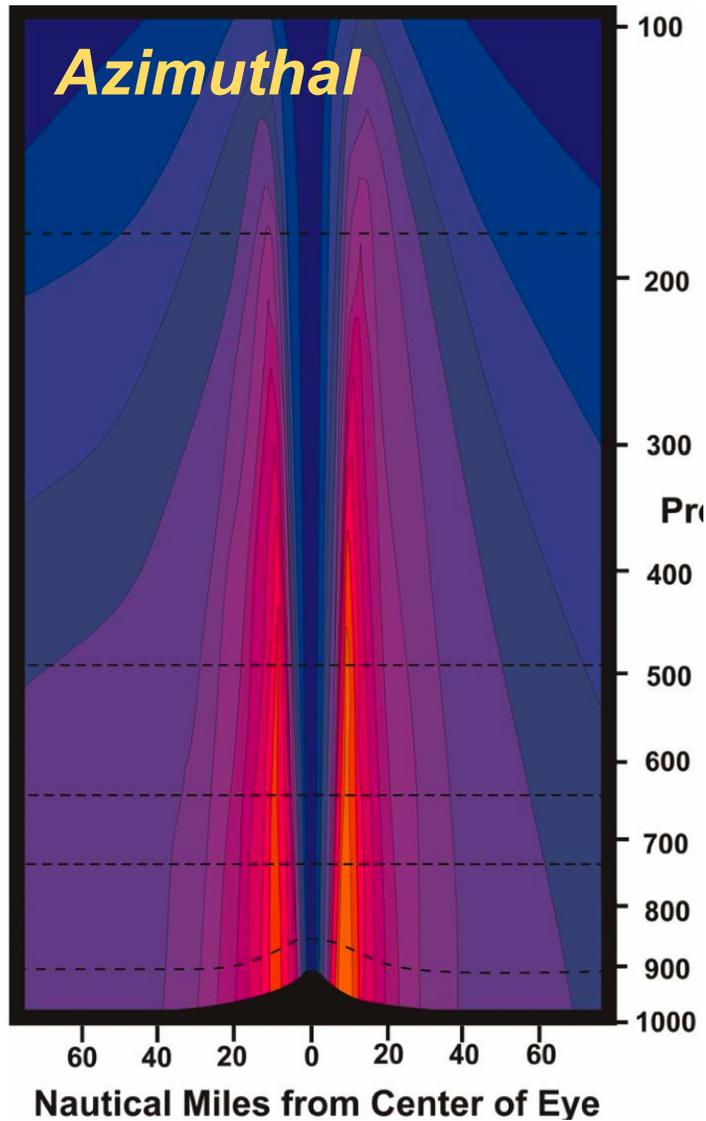
# Hurricane Isidore cross-section



# Hurricane Inez thermal structure

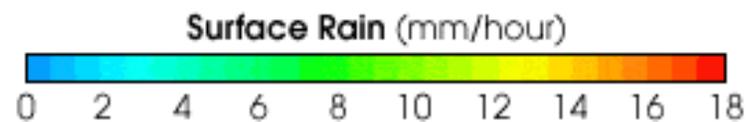
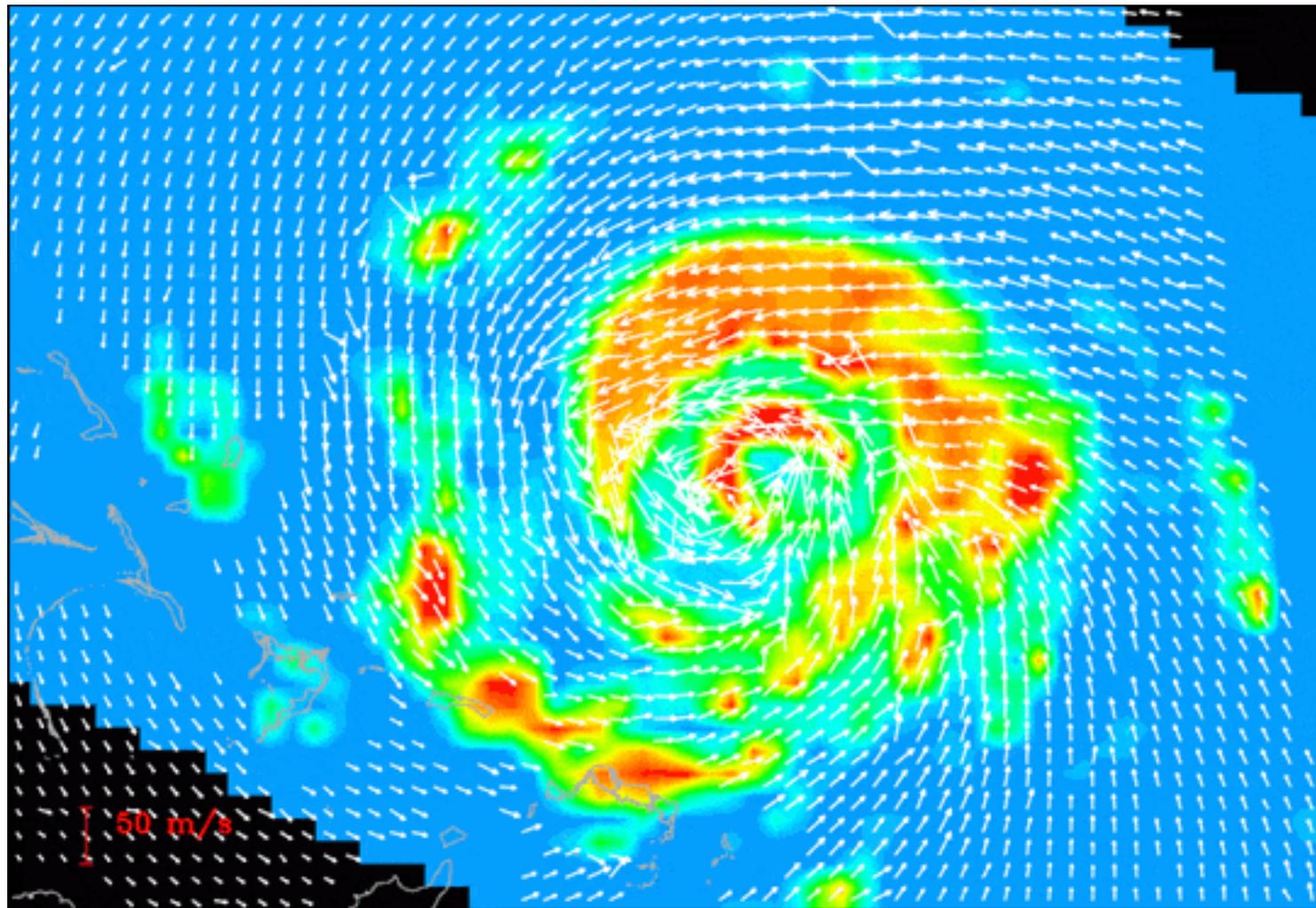


# 3D wind structure

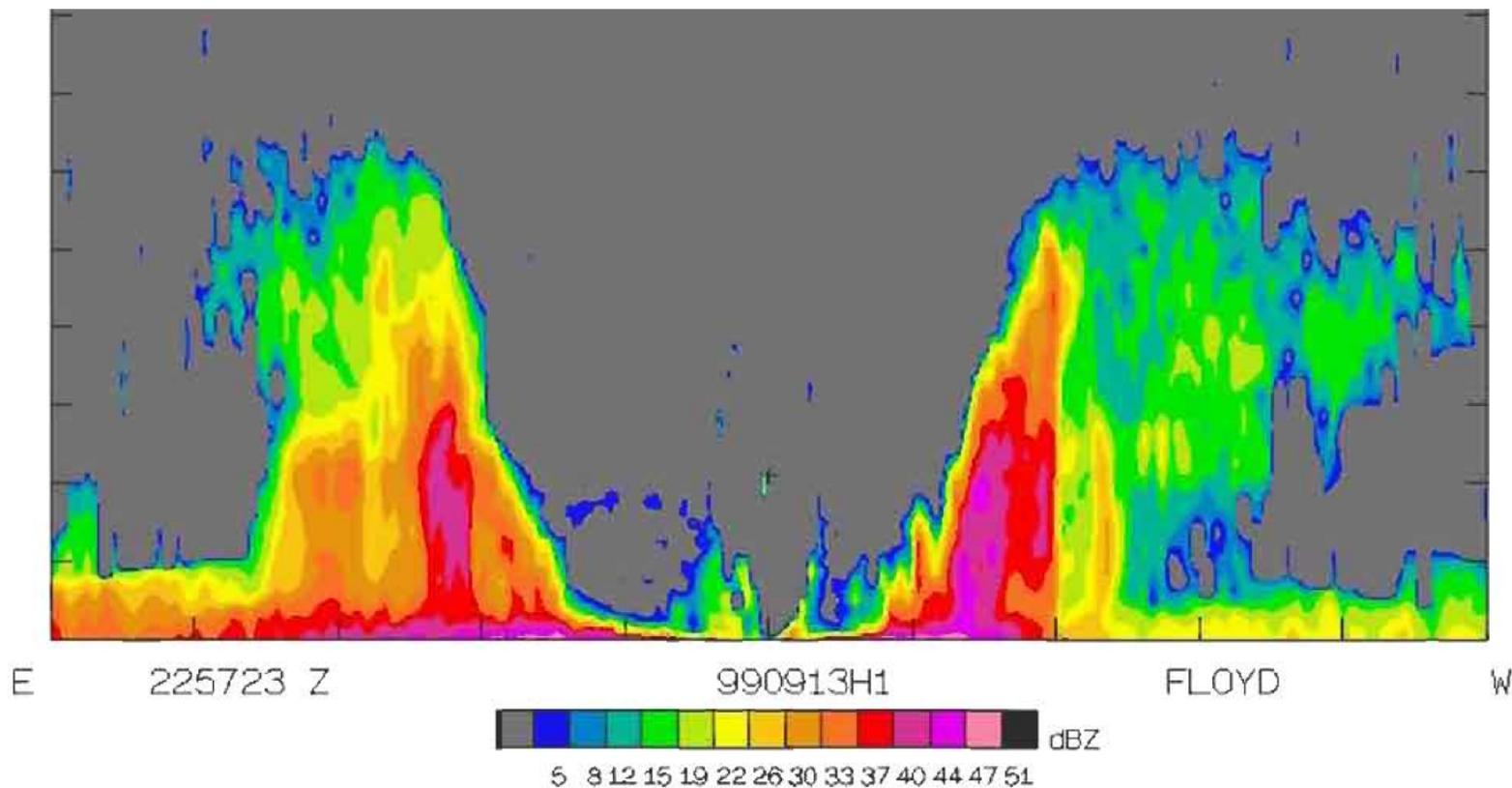


*Emanuel 2005*

# Hurricane Floyd: Surface winds, prec



# Hurricane Floyd: Radial-height prec



(min.) (max.)  
Pitch= .9; 1.2  
Roll= -2; 6.4  
Track=187.5;189.2

(min.) (max.)  
Drift= 5.6; 6.7  
Tilt= -26.0; -1.3  
120 X 20 km

Tail Radar  
Alt= 4243 m  
Rlat= 24.56 N  
Rlon= 73.86 W