

1

The Tropics

- Located 23½° N to 23½° S

- Large amount of solar radiation
- Little seasonal variation
- Warm water → tremendous latent heat source
- High relative humidity promotes cumulus cloud development
- Surface winds from the east

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What are Tropical Cyclones?

- A cyclone that originates over warm, tropical oceans
- Includes tropical depressions, tropical storms, hurricanes, and typhoons
- Different structure than midlatitude frontal cyclones → no fronts!

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Atlantic Hurricane Season

The official Atlantic hurricane season is from June 1 to November 30

NOAA

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Optimal Conditions for Tropical Cyclone Development

- Sea surface temperatures > 80°F (> 26.5°C)
 - Deep layer of warm water
- No significant land mass interaction
 - Avoids dry air entrainment (mixing with dry air)
 - Retains source of energy: evaporation
- Favorable wind profiles
 - Vertical: little to no vertical shear
 - Horizontal: surface wind convergence

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Formation Mechanisms

- Inter-Tropical Convergence Zone (ITCZ)
 - Persistent thunderstorm formation
- Stalled cold fronts over very warm waters
 - Enhanced convective activity
- *Easterly waves
 - Forces surface convergence (→ lifting)

Tropical easterly waves are the usual mechanism


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Stages of Development

- Tropical (“Easterly”) Wave
- Tropical Disturbance
- Tropical Depression (given a number)
- Tropical Storm (given a name)
- Hurricane (categories 1 thru 5)

Increasing Organization
↓

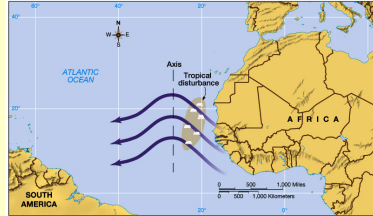


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Tropical (“Easterly”) Waves

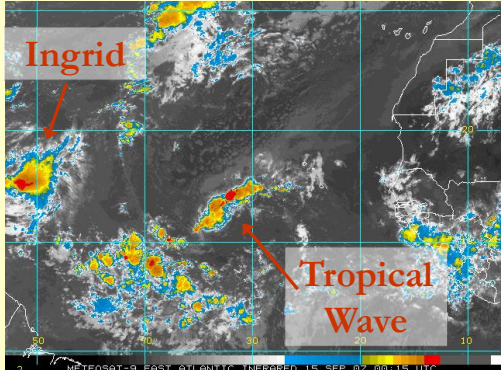
- Troughs of low pressure
 - Found in the easterly trade winds
- Migrate westward at low latitudes
 - i.e., they move from east to west
- Surface wind convergence
 - On the east side of the trough axis



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Tropical (“Easterly”) Wave




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Tropical Disturbance

- Broad area of disorganized clusters of thunderstorms
- Commonly exist only 24 to 48 hours




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Key question: Can thunderstorm convection maintain itself?
 □ Critical to future intensification
 The tropical disturbance that would become Hurricane Humberto

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Tropical Depression

- A tropical system that has a closed wind circulation
- Winds typically range from 20–38 m.p.h.
- Given a “number” by National Hurricane Center
 - Subsequently tracked



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Tropical Depression



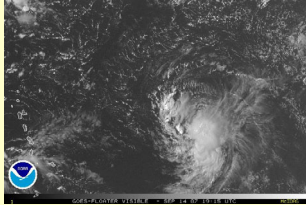
18 September 2005: The tropical depression that would become Hurricane Rita

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Tropical Storm

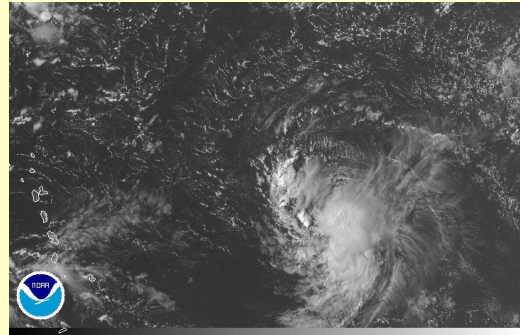
- Definition: a cyclonic circulation originating over tropical oceans with sustained surface winds of at least **39 m.p.h.**
- Tropical storm gets a name



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Tropical Storm



14 September 2007: Tropical Storm Ingrid at 3:15 p.m. EDT

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Atlantic Storm Names

2026	2027	2028	2029	2030	2031
Arthur	Ana	Alex	Arlene	Alberto	Andrea
Bertha	Bill	Bonnie	Bret	Brianna	Barry
Cristobal	Claudette	Colin	Cindy	Chris	Chantal
Dolly	Danny	Danielle	Don	Debby	Dexter
Edouard	Elsa	Earl	Emily	Ernesto	Erin
Fay	Fred	Farrah	Franklin	Francine	Fernand
Gonzalo	Grace	Gaston	Gert	Gordon	Gabrielle
Hanna	Henri	Hermine	Harold	Holly	Humberto
Isaias	Imani	Idris	Idalia	Isaac	Imelda
Josephine	Julian	Julia	Jose	Joyce	Jerry
Kyle	Kate	Karl	Katia	Kirk	Karen
Leah	Larry	Lisa	Lee	Leslie	Lorenzo
Marco	Mindy	Martin	Margot	Miguel	Molly
Nana	Nicholas	Nicole	Nigel	Nadine	Nestor
Omar	Odette	Owen	Ophelia	Oscar	Olga
Paulette	Peter	Paula	Philippe	Patty	Pablo
Rene	Rose	Richard	Rina	Rafael	Rebekah
Sally	Sam	Shary	Sean	Sara	Sebastien
Teddy	Teresa	Tobias	Tammy	Tony	Tanya
Vicky	Victor	Virginie	Vince	Valerie	Van
Wilfred	Wanda	Walter	Whitney	William	Wendy

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Hurricane

- Maximum sustained winds of at least **74 m.p.h.**
- Most organized stage of a tropical cyclone
 - Well-defined structure with distinct parts
- Positive feedback mechanism at its finest
 - Can last more than 20 days in some cases
 - Can travel over 1000 km
- Categorized further based on intensity

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Hurricane Classification

Saffir-Simpson Scale

5 categories based on intensity

Table 12-2 The Saffir-Simpson Scale

Category	Pressure mb	Wind Speed		Storm Surge		Damage
		km/hr	mph	m	ft	
1	≥ 980	119–154	74–95	1–2	4–5	Minimal
2	965–979	155–178	96–110	2–3	6–8	Moderate
3	945–964	179–210	111–130	3–4	9–12	Extensive
4	920–944	211–250	131–155	4–6	13–18	Extreme
5	< 920	> 250	> 155	> 6	> 18	Catastrophic

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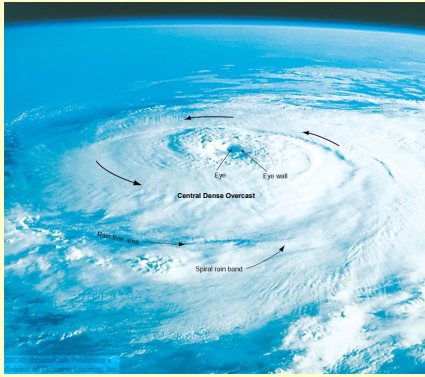
Hurricane Structure

- Eye
- Eye wall
- Central dense overcast
- Spiral rain bands
- Rain-free area

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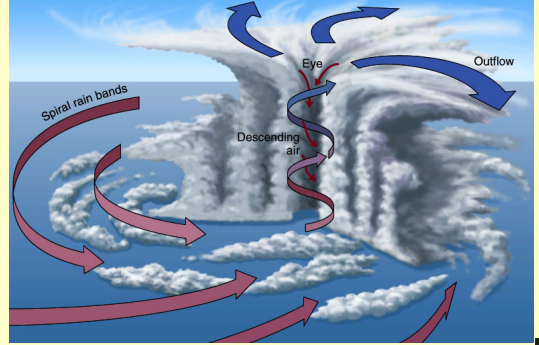
Hurricane Structure



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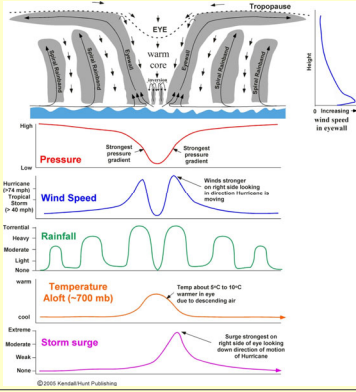
Vertical Slice of a Hurricane



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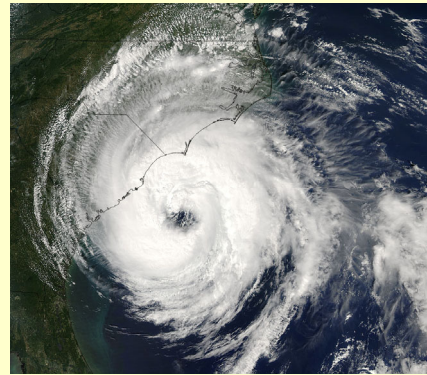
Hurricane Structure



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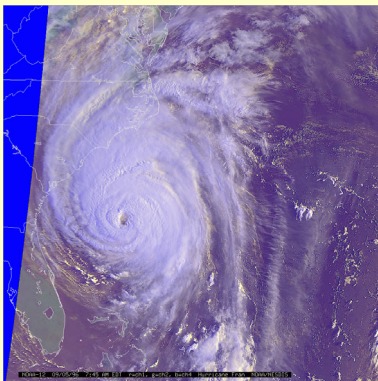
Hurricane Ophelia – Category 1 (2005)



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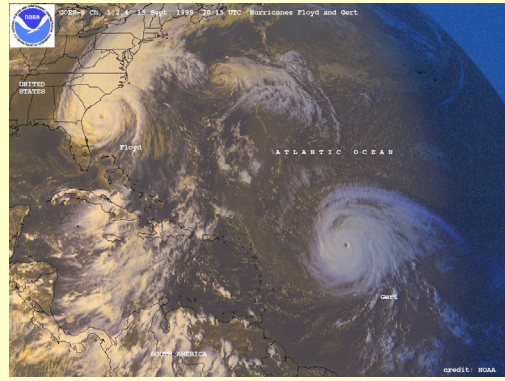
Hurricane Fran – Category 3 (1996)



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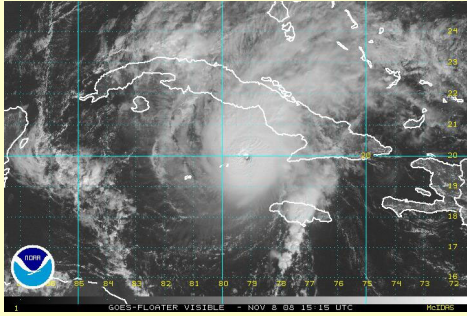
Hurricane Gert – Category 4 (1999)



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Hurricane Paloma – Category 4 (2008)



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Hurricane Katrina – Category 5 (2005)



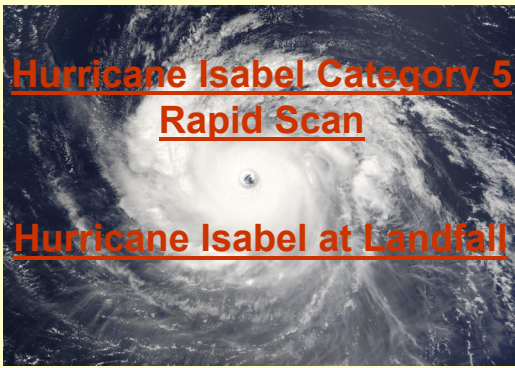
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Hurricane Isabel – Category 5 (2003)

Hurricane Isabel Category 5
Rapid Scan

Hurricane Isabel at Landfall



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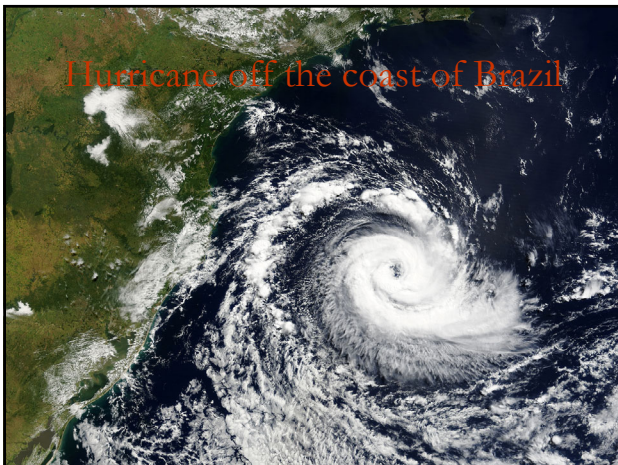
Hurricanes Around the World

- Atlantic and Central/East Pacific: **Hurricanes**
- Western Pacific: **Typhoons**
 - Formerly “willy-willy” in Australia, but that’s also the name for an Australian dust devil
- South Pacific/Indian Oceans: **Cyclones**
- Most common in West Pacific
 - Can occur year-round
- Rare in South Atlantic

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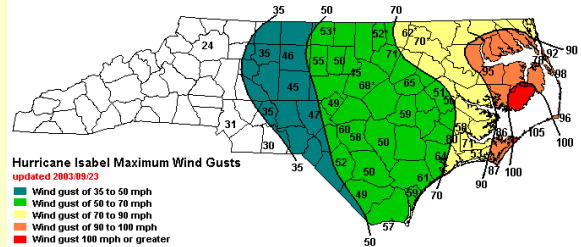
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Hurricane off the coast of Brazil



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Hurricane Dangers: Straight-line winds



* Note that 68 mph gusts in Wake county observed atop the 7th floor of Jordan Hall at NC State University
* Measurements made in Vance and Halifax counties were before the equipment there failed and are likely under done.

Data analysis - Phillip Badgett
Graphic - Jonathan Blass
HWS Raleigh, NC
www.erh.noaa.gov/rah

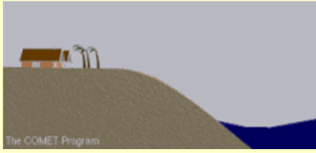
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Hurricane Dangers: Storm Surge

Sea Water Pushed Onshore by Wind

- High terrain
- Steep slope
- Less surge danger



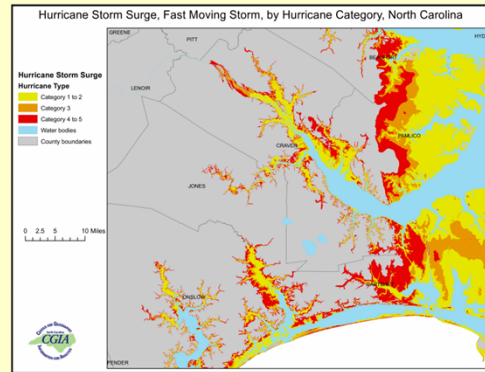
- Low terrain
- Gentle slope
- More surge danger



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Hurricane Dangers: Storm Surge

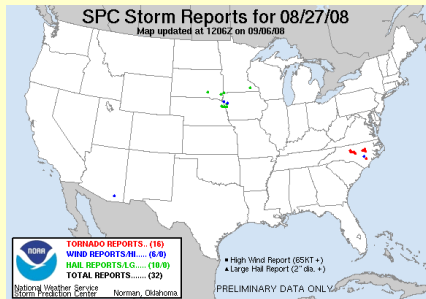


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Hurricane Dangers: Tornadoes

- Frictional drag enhances vertical shear
- Generally weak (EF0 to maybe EF2)



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Hurricane Dangers: Inland Rain



Do you recognize this place?

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Hurricane Dangers: Inland Rain



Inland flooding is the **deadliest** hurricane killer

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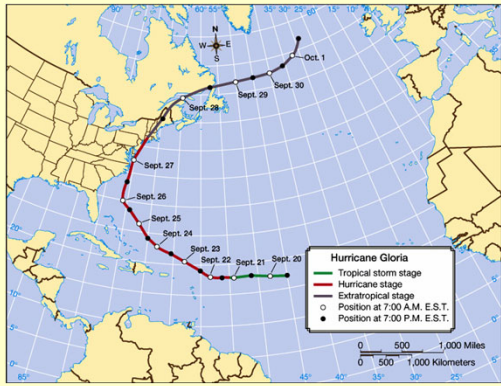
Storm Motion

- Tropical storms are guided by upper-level flow
 - Initially guided westward by surface trade winds
 - Tend to "recurve" to northeast as these storms approach the middle latitudes
- Flow can steer storms out to sea or toward land

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Storm Motion



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Forecasting

- Computer models simulate storm's environment and predict its motion
- Approach to land triggers **watches** and **warnings**

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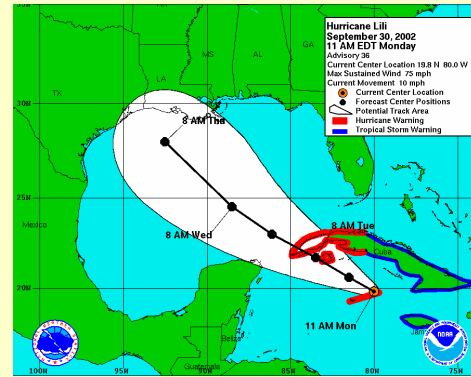
Forecasting

- Hurricane **Watch**:
 - Hurricane conditions (winds >74 m.p.h.) *possible* in 48 hrs
- Hurricane **Warning**:
 - Hurricane conditions *expected* within 36 hrs
- Same procedure for tropical storm watches/warnings

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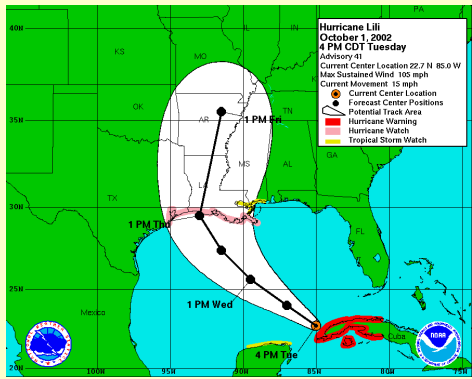
Forecasting



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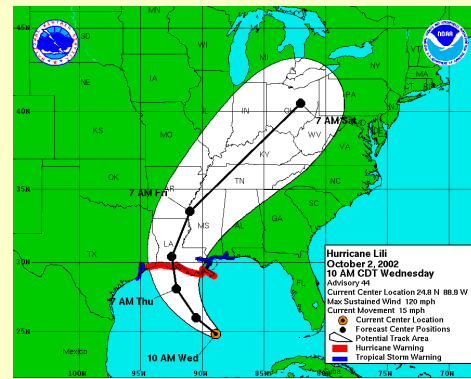
Forecasting



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Forecasting



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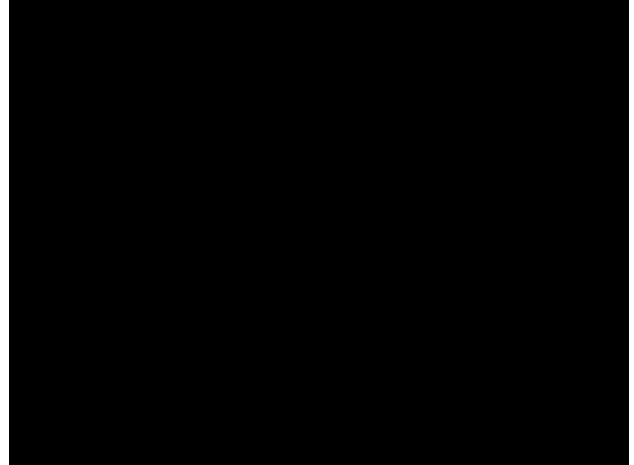
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Visit the National Hurricane Center for more information (www.nhc.noaa.gov)



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Extras



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