

# Tornadoes AOSC 200

Tim Canty

Class Web Site: <http://www.atmos.umd.edu/~tcanty/aosc200>

Topics for today:

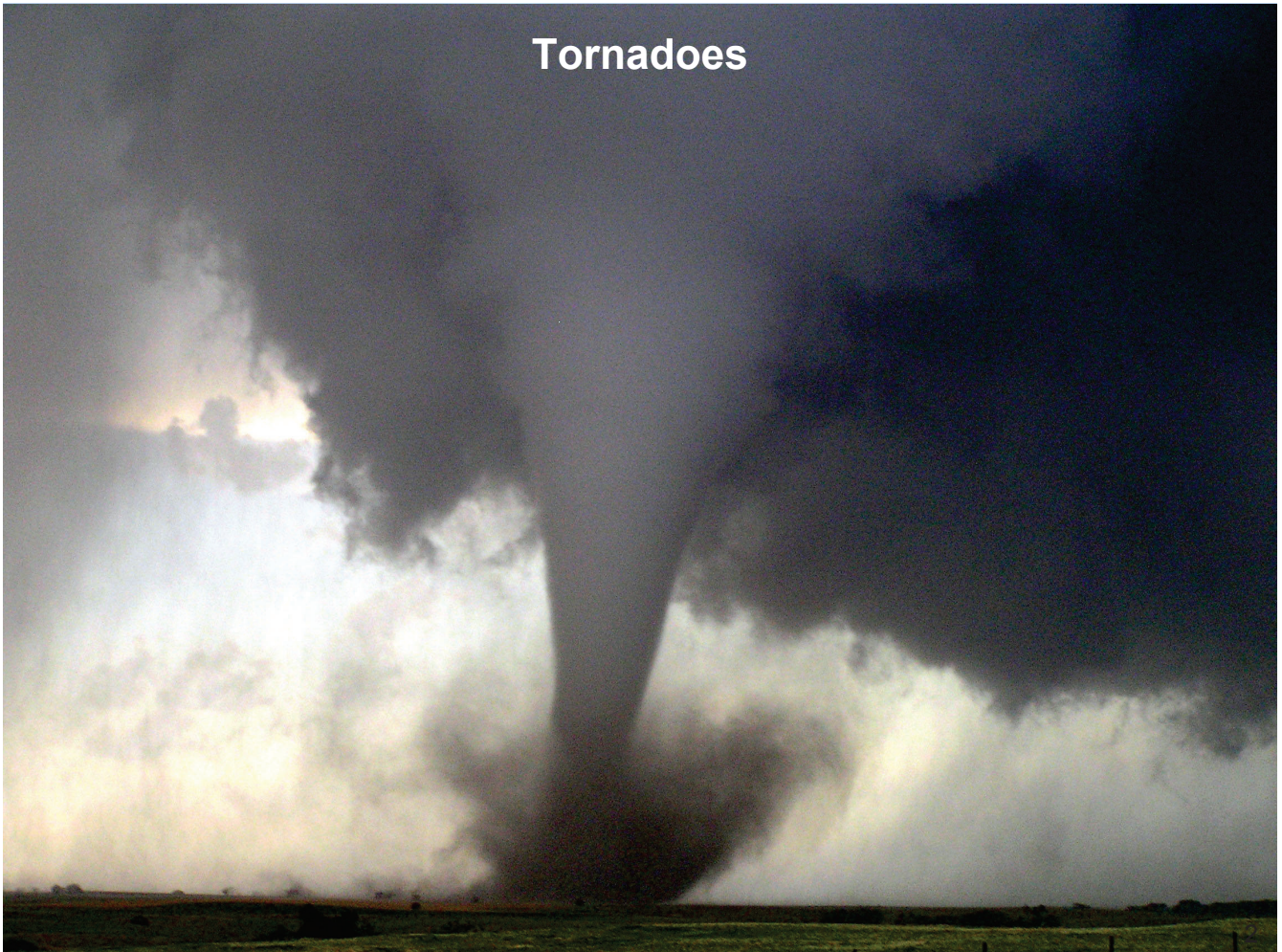
**Tornadoes and Hurricanes**

**Lecture 24  
Nov 19 2019**

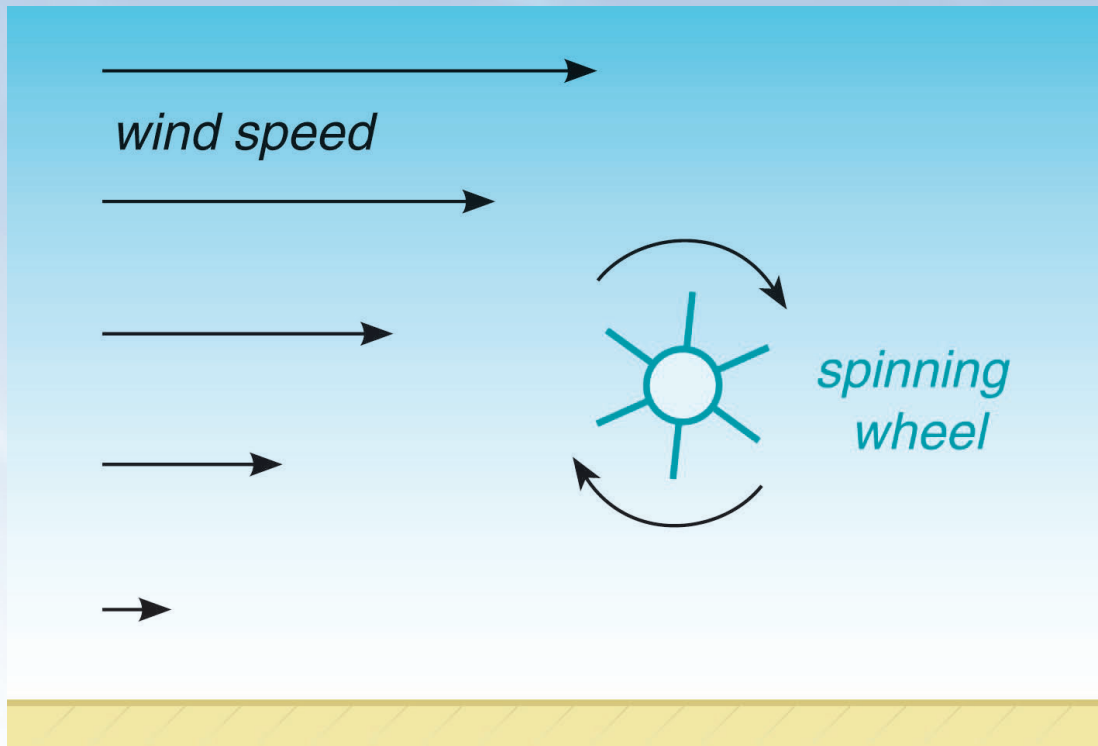
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## Tornadoes



## Supercells Thunderstorms

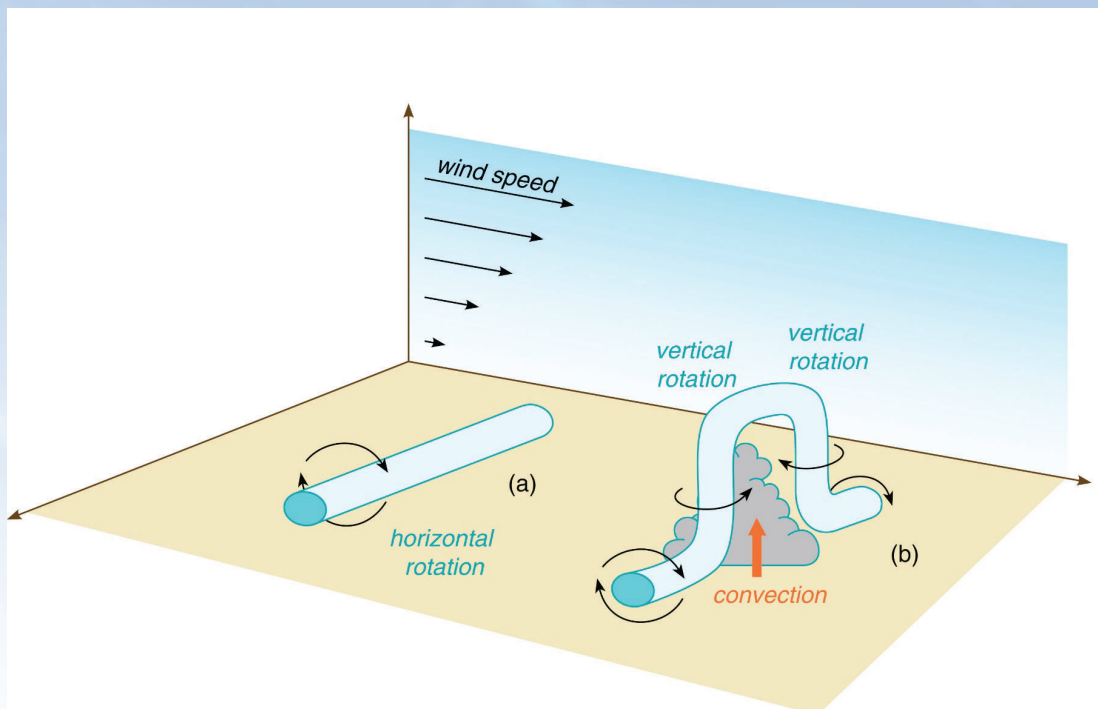


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Fig 11-10 *Weather A Concise Introduction*

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## Supercells Thunderstorms

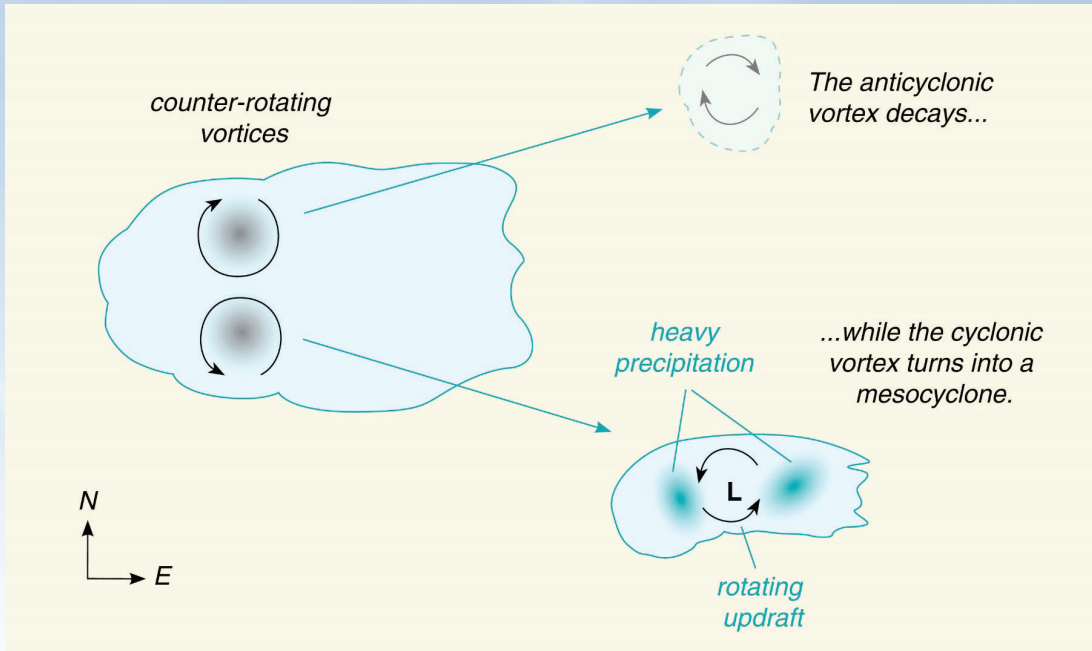


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Fig 11-11 *Weather A Concise Introduction*

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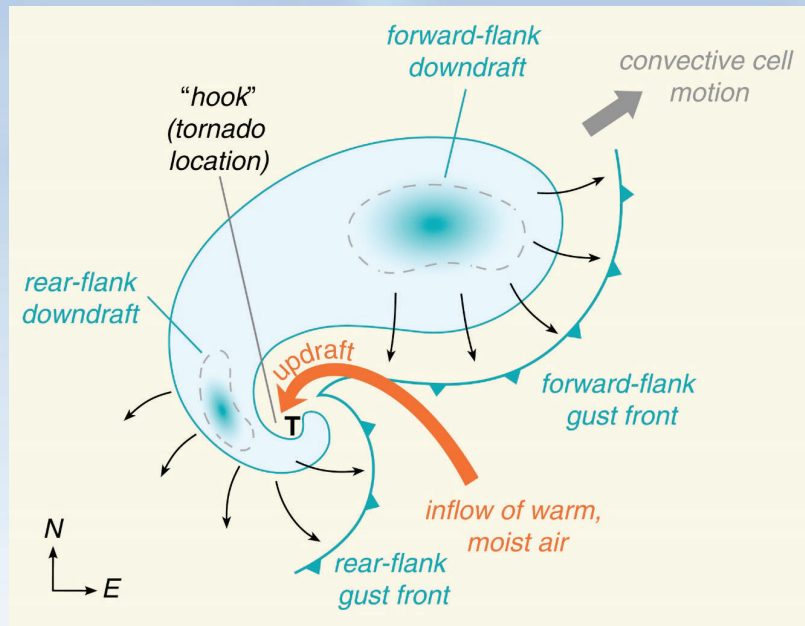
# Supercells Thunderstorms



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Fig 11-12 Weather A Concise Introduction

# Tornadoes



**Cold downdraft supports strong updraft**

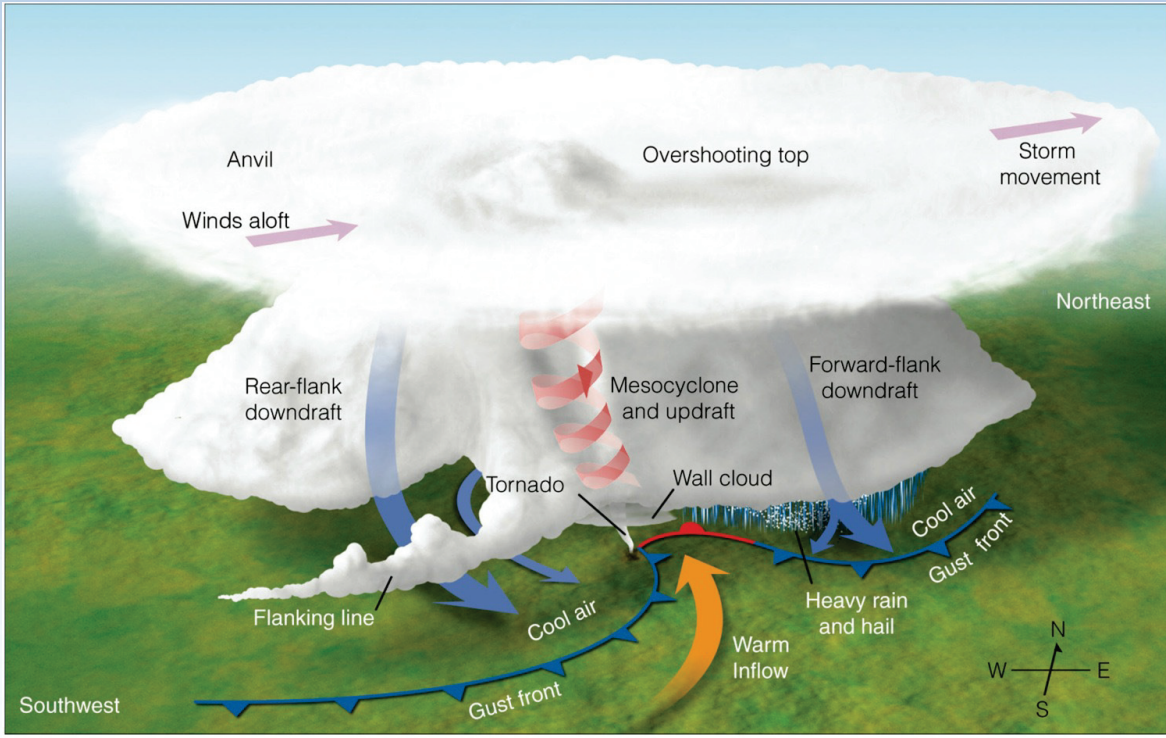
**Warm, moist air brought in to storm where up and down drafts meet**

**Tornado typically forms on southern edge of storm**

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Fig 11-13 Weather A Concise Introduction

# Supercells Thunderstorms



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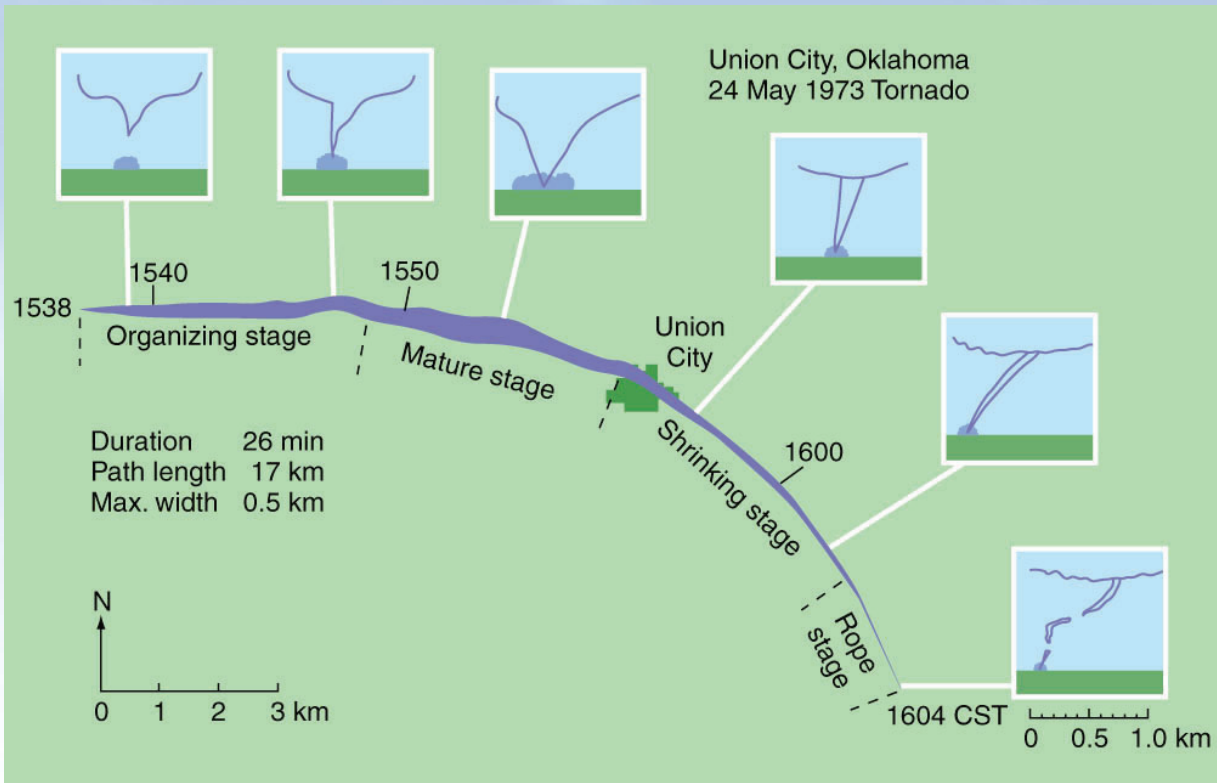
**Strong winds aloft brought down to surface may lead to tornado  
Cell may last several hours**

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**Fig 10-47** *Essentials of Meteorology*

# Tornadoes: Life Cycle



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## Tornadoes: Winds

**TABLE 10.2** Enhanced Fujita (EF) Scale for Damaging Tornado Winds

EF SCALE	CATEGORY	MI/HR*	KNOTS*
EF0	Weak	65–85	56–74
EF1		86–110	75–95
EF2	Strong	111–135	96–117
EF3		136–165	118–143
EF4	Violent	166–200	144–174
EF5		>200	>174

\*The wind speed is a 3-second gust estimated at the point of damage, based on a judgment of damage indicators.

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**Enhanced Fujita Scale: based on 28 damage indicators such as types of damage to different structures (barns, motels, schools, etc.).**

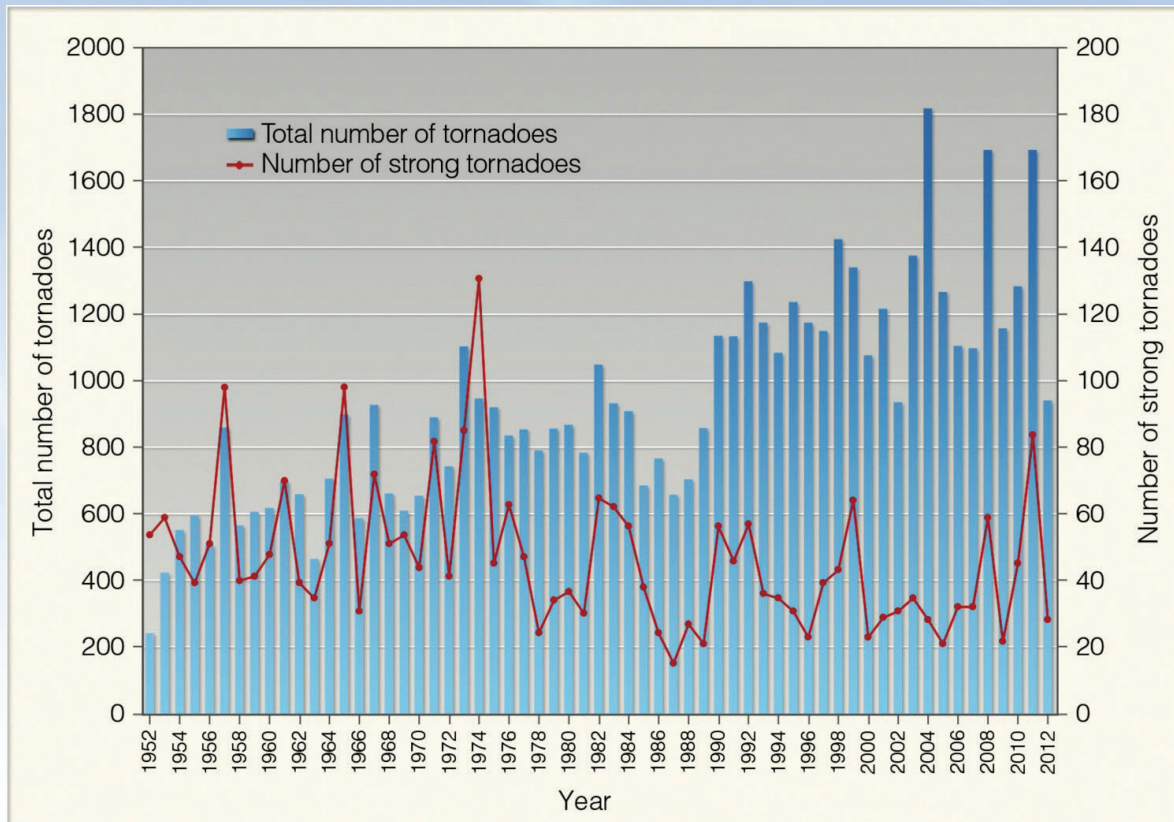
Table 10-2 Essentials of Meteorology

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## Tornadoes: United States



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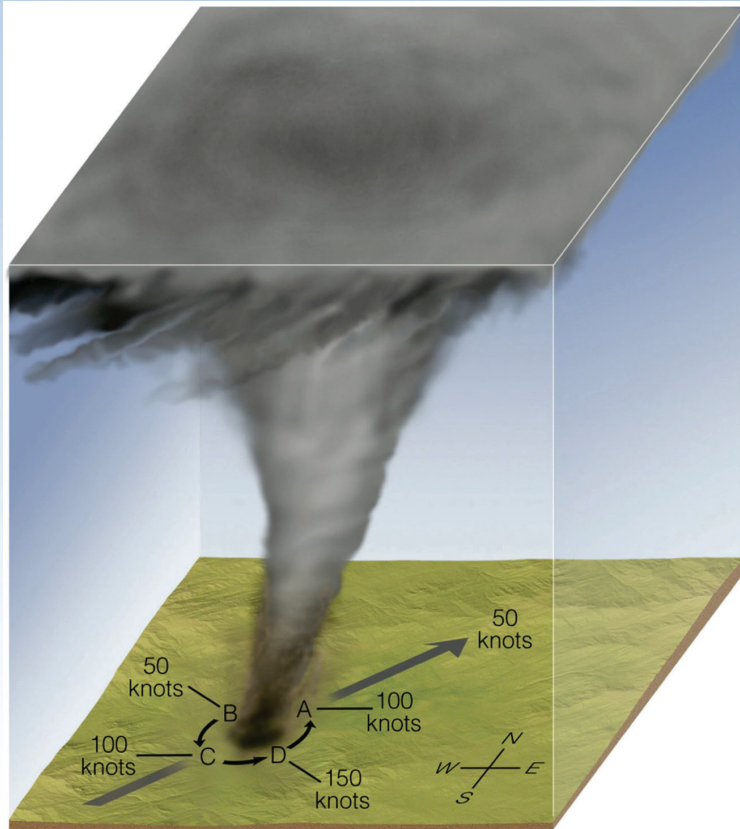
Fig 10-35 Essentials of Meteorology

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# Tornadoes: Winds



Wind damage is caused by

- 1) The surface speed of the tornado
- 2) The rotation speed of the tornado

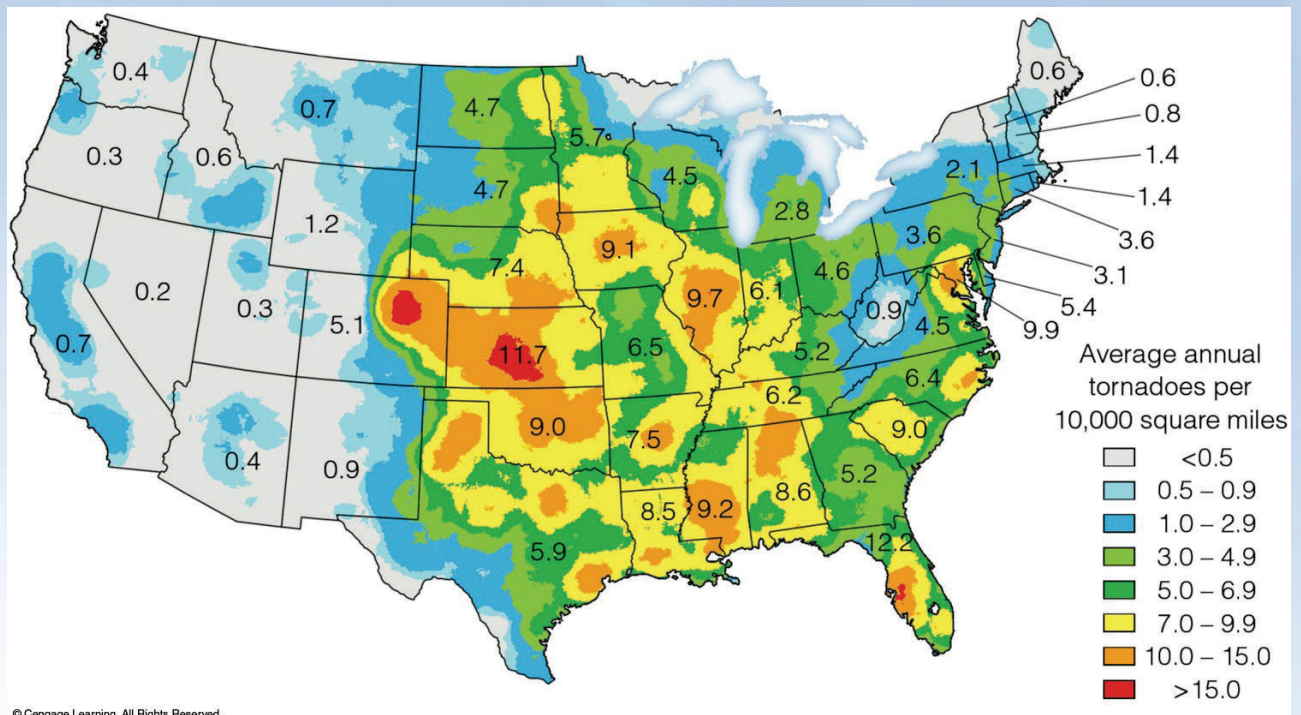
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Fig 10-38 *Essentials of Meteorology*

# Tornado Frequency



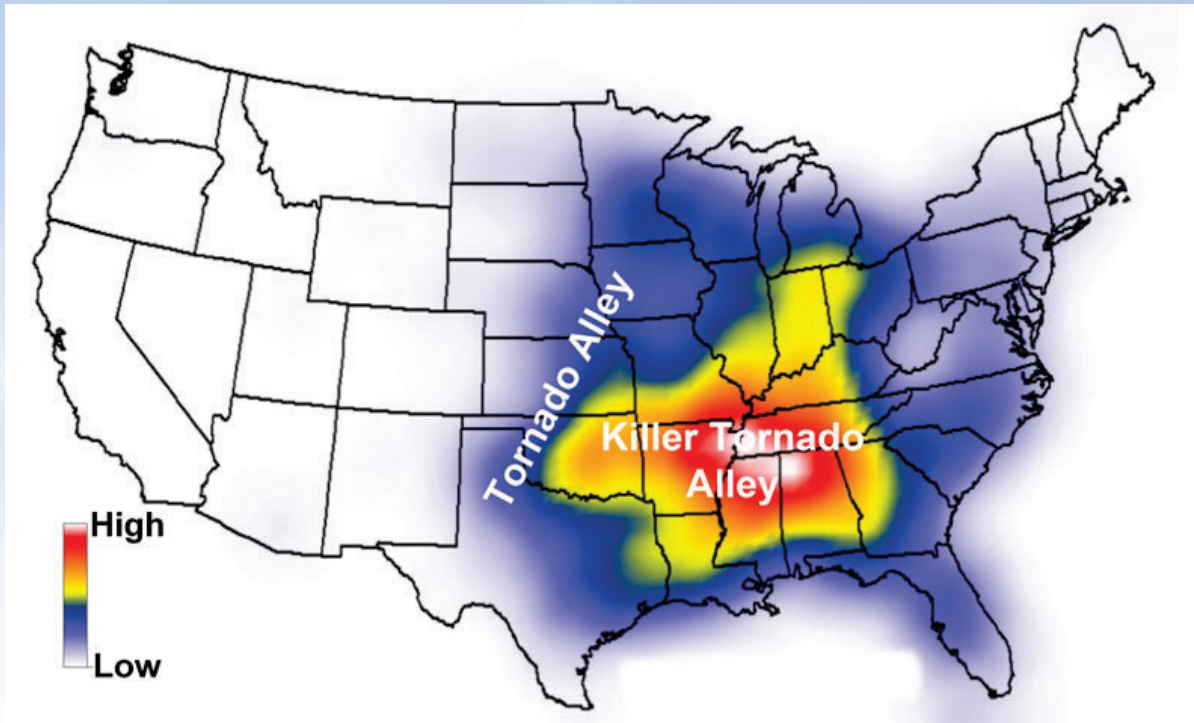
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Fig 10-36 *Essentials of Meteorology*

## Tornado Death Frequency



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Fig 11-27 *Meteorology: Understanding the Atmosphere*

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## Tropical Cyclone

### Known by several names:

- Hurricanes – Atlantic Ocean, Eastern North Pacific
- Typhoons – Pacific Ocean
- Cyclones – Indian Ocean

**Must have minimum wind speed of 74 mph and rotational circulation**

**“Major Hurricane” – Category 3 or higher**

**“Super Typhoon” – Category 4 or higher**

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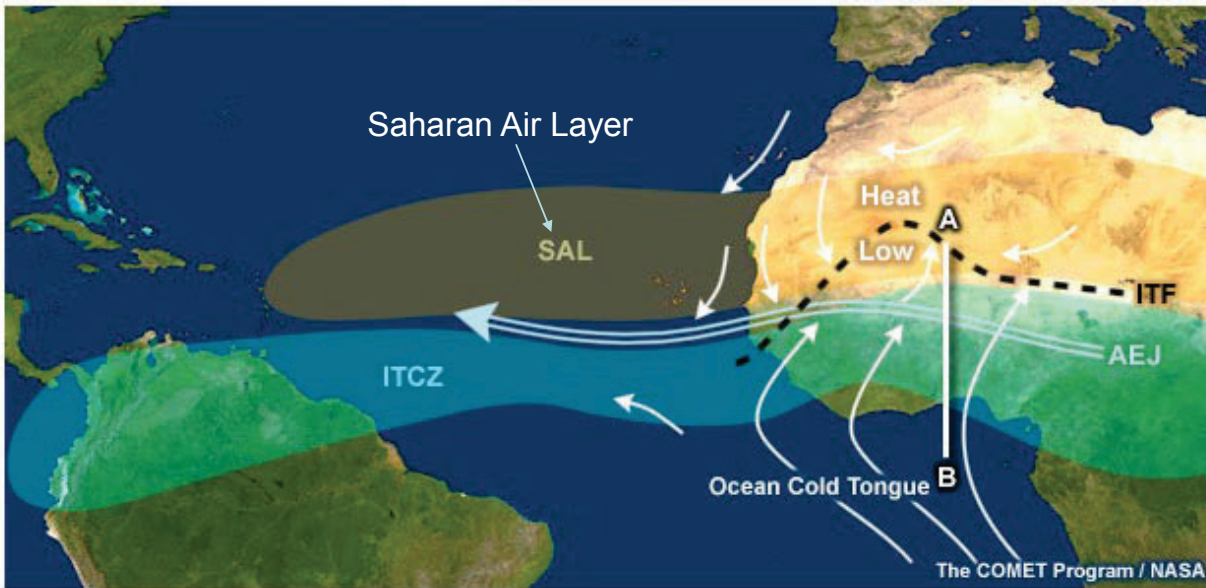
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## Tropical Cyclone: African Easterly Jet

### Tropical Disturbance:

- Mid-level, Easterly winds blowing off of the hot Sahara



[http://www.meted.ucar.edu/dynamics/thermal\\_wind/navmenu.php?tab=1&page=11.4.0&type=text](http://www.meted.ucar.edu/dynamics/thermal_wind/navmenu.php?tab=1&page=11.4.0&type=text)

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## Tropical Cyclone: Life Cycle

### Tropical Disturbance:

- Tropical weather system 100 to 300 nmi in diameter
- Originates in tropics or subtropics
- May be associated with perturbations in the wind field known as **easterly waves**.



<http://www.aoml.noaa.gov/hrd/tcfaq/A4.html>

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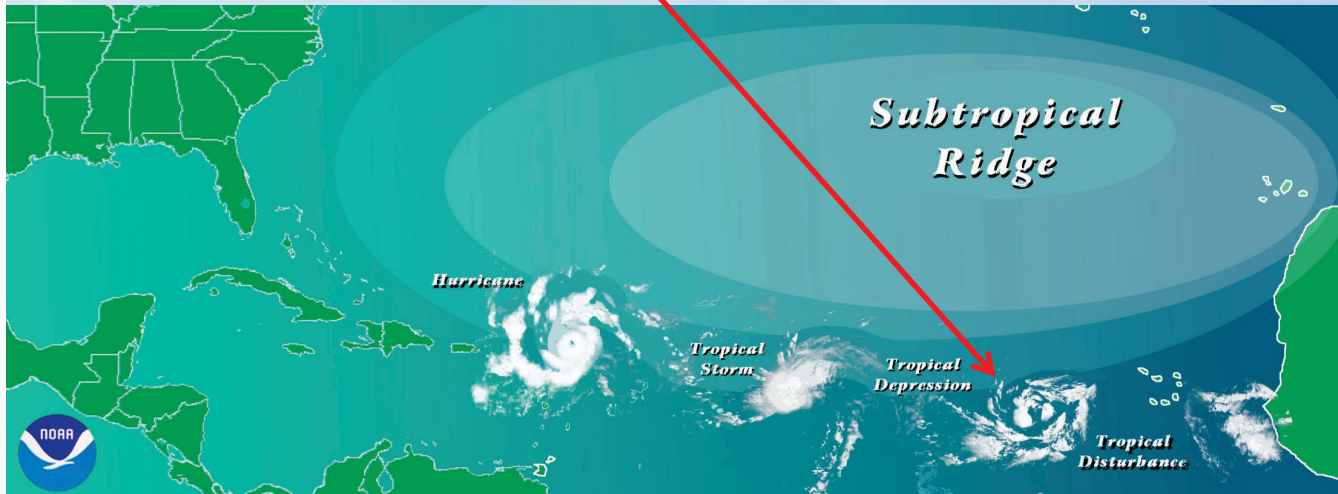
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## Tropical Cyclone: Life Cycle

### Tropical Depression:

- Maximum sustained surface wind speed up to 38 mph
- Depressions have a closed circulation
- Weak low pressure center ~1010 mb



## Tropical Cyclone: Life Cycle

### Tropical Storm:

- Maximum sustained surface wind speed 39 mph to 73 mph
- Convection usually more concentrated near the center
- Outer rainfall organizing into distinct bands
- Central pressure ~1000 mb



# Saffir-Simpson Scale

**TABLE 11.2** Saffir-Simpson Hurricane Damage-Potential Scale

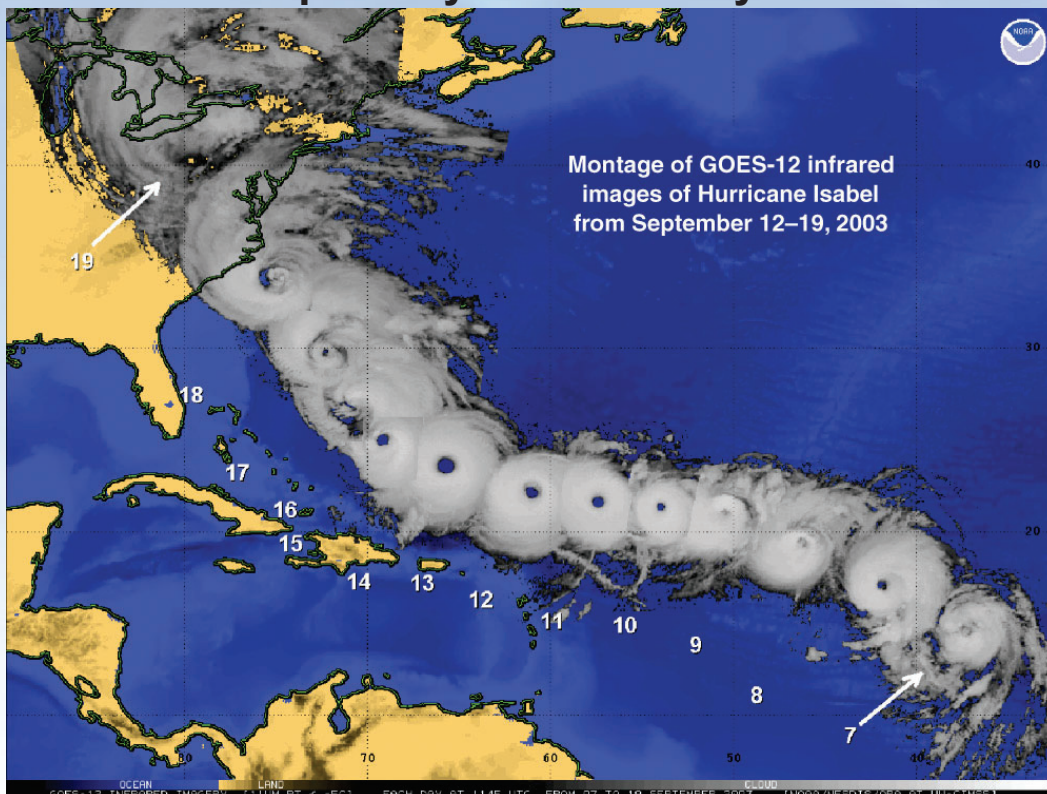
SCALE NUMBER (CATEGORY)	CENTRAL PRESSURE		WINDS		STORM SURGE		DAMAGE
	mb	in.	mi/hr	knots	ft	m	
1	≥980*	≥28.94	74–95	64–82	4–5	~1.5	Damage mainly to trees, shrubbery, and unanchored mobile homes
2	965–979	28.50–28.91	96–110	83–95	6–8	~2.0–2.5	Some trees blown down; major damage to exposed mobile homes; some damage to roofs of buildings
3	945–964	27.91–28.47	111–130	96–113	9–12	~2.5–4.0	Foliage removed from trees; large trees blown down; mobile homes destroyed; some structural damage to small buildings
4	920–944	27.17–27.88	131–155	114–135	13–18	~4.0–5.5	All signs blown down; extensive damage to roofs, windows, and doors; complete destruction of mobile homes; flooding inland as far as 10 km (6 mi); major damage to lower floors of structures near shore
5	<920	<27.17	>155	>135	>18	>5.5	Severe damage to windows and doors; extensive damage to roofs of homes and industrial buildings; small buildings overturned and blown away; major damage to lower floors of all structures less than 4.5 m (15 ft) above sea level within 500 m of shore

\*Symbol > means “greater than”; < means “less than”; ≥ means “equal to or greater than”; ~ means “approximately equal to.”

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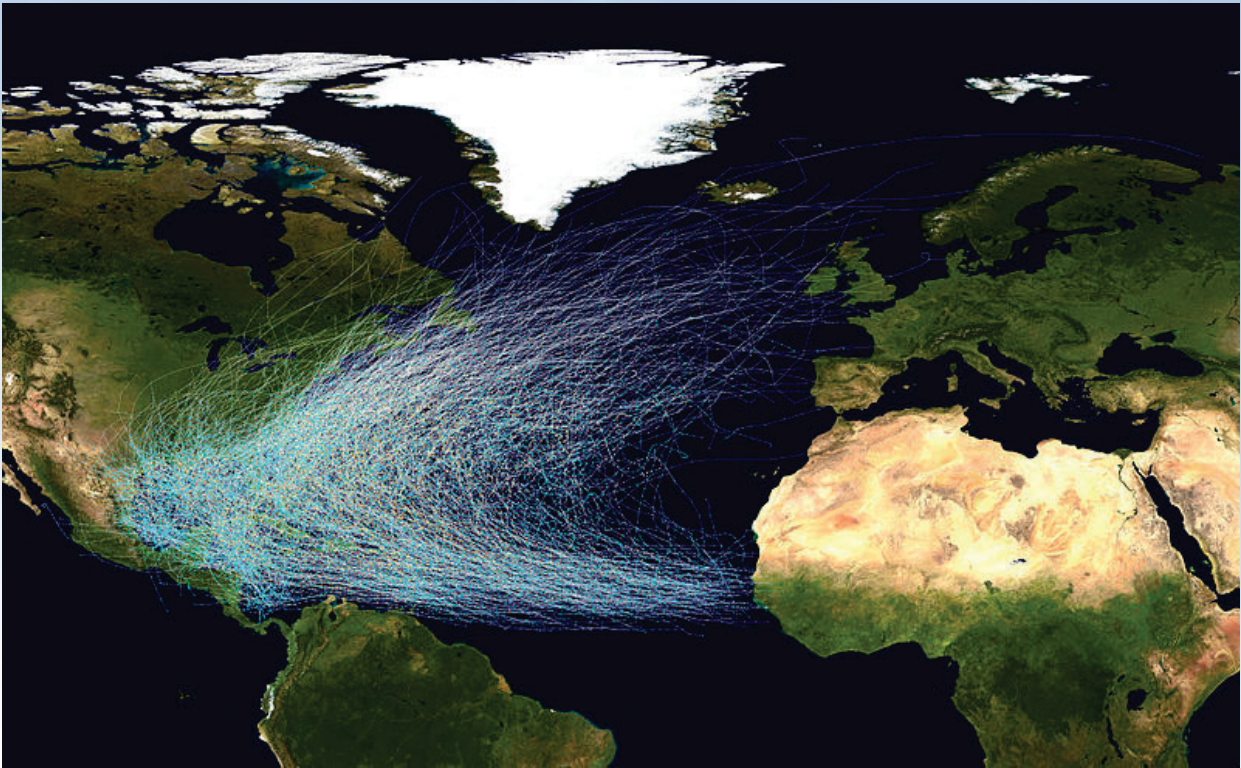
## Tropical Cyclone: Life Cycle



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# Hurricanes: 1851–2012



**Hurricane Season: June 1 – November 30**

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## Recurvature: the “C” shaped path of Hurricanes



**Hurricanes track around the Bermuda High  
When they turn North, Westerly jet stream pushes hurricanes to North-East**

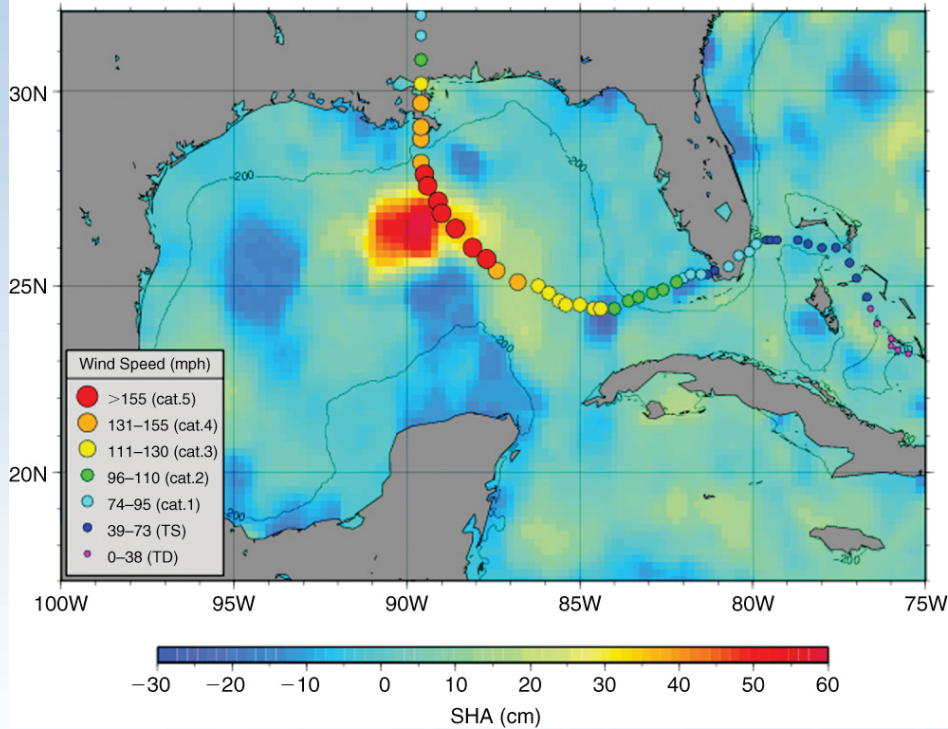
<http://www.wunderground.com/blog/BDawx/archive.html?year=2010&month=07>

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# Tropical Cyclone: Life Cycle

Gulf of Mexico—Sea height anomaly (SHA) 08/28/2005  
Hurricane Katrina

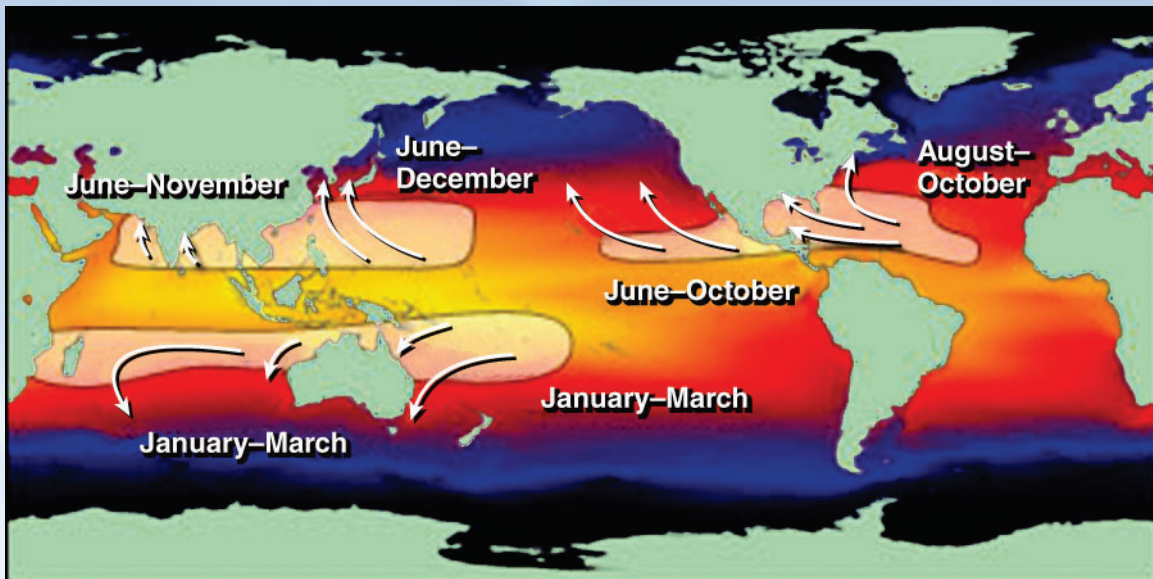


**Strongly affected by sea surface temperature**

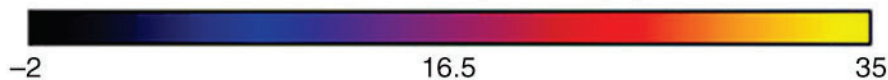
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**Fig 8-32** *Meteorology: Understanding the Atmosphere* 23

# Tropical Cyclone: Role of SST



Sea Surface Temperature (C)

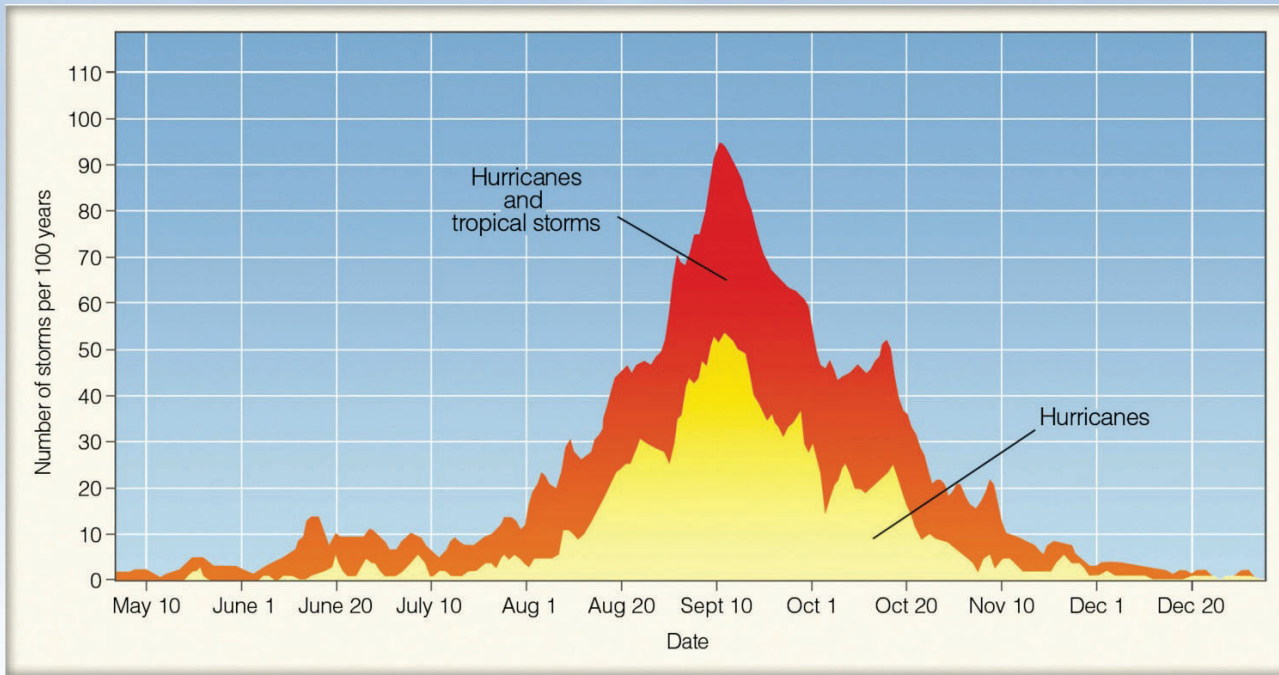


**Need SST greater than 26.5°C (found in the tropics)**  
**Evaporation increases quickly with rising temperature**  
**Latent heat provides energy to storm**

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**Fig 8-23** *Meteorology: Understanding the Atmosphere* 24

# Hurricane Season



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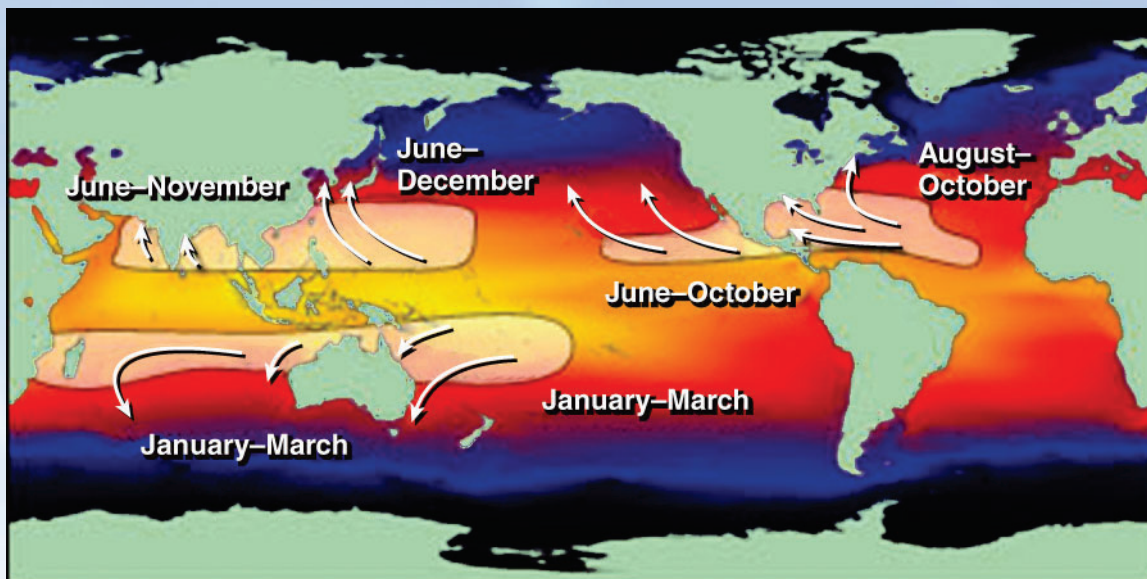
Fig 11-6 *Essentials of Meteorology*

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## Tropical Cyclone: Why no cyclones near the equator?



Sea Surface Temperature (C)



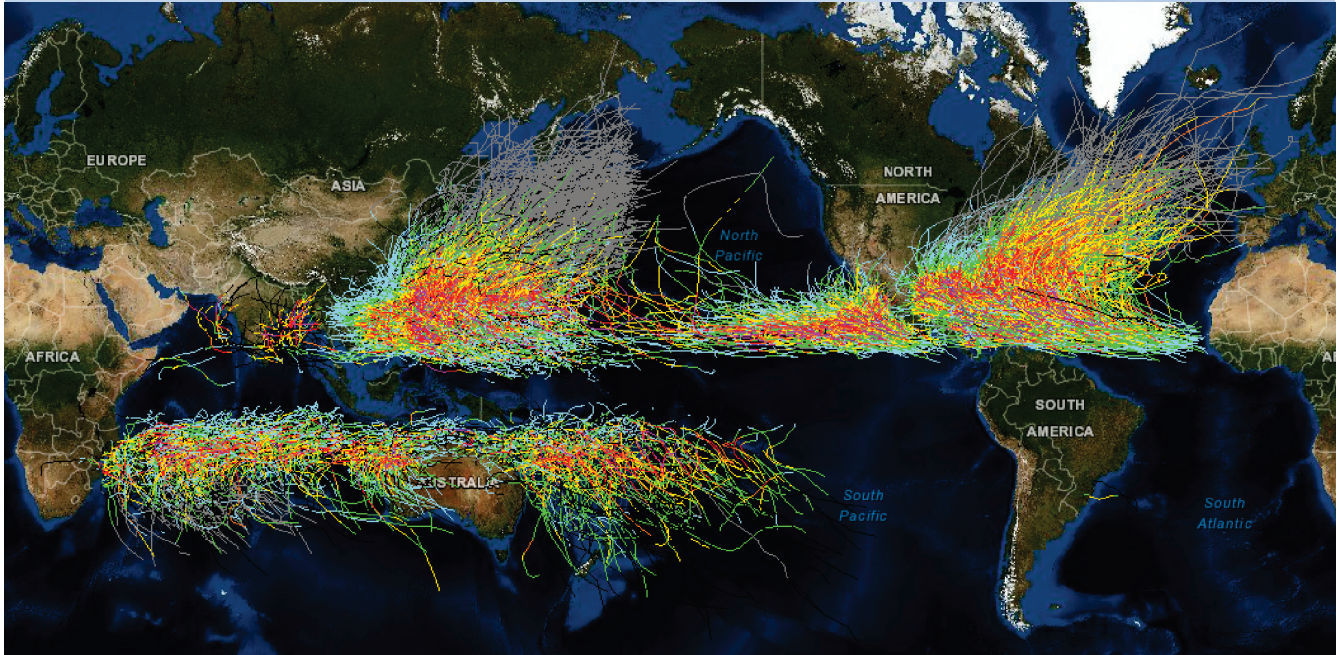
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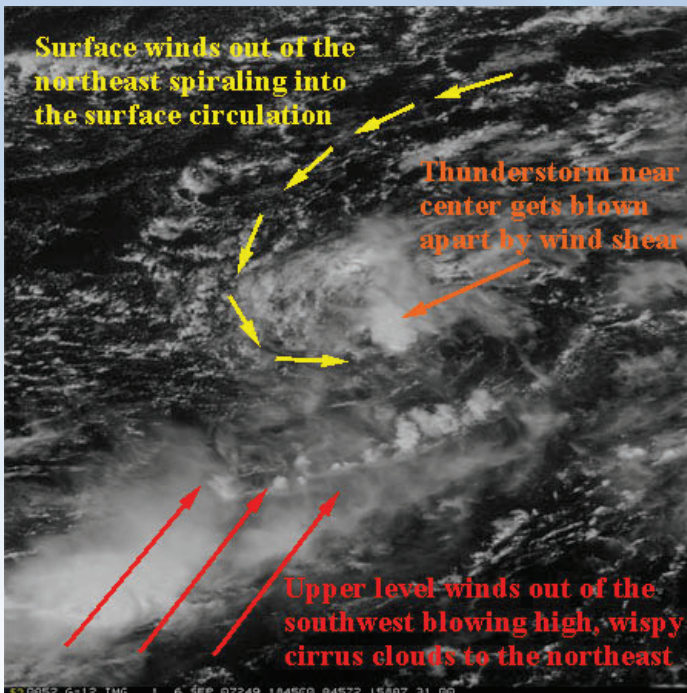
# Tropical Cyclone: 1848-2013



<http://coast.noaa.gov/geozone/hurricane-tracks-past-present-future/#.VUjdoY5Vikp>

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## Tropical Cyclone: Role of Wind Shear



<http://www.wunderground.com/education/shear.asp>

**Wind shear can rip apart storms before they can coalesce into a cyclone**  
**Winds spread out release of latent heat over large area**

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## Tropical Cyclone: End of the storm

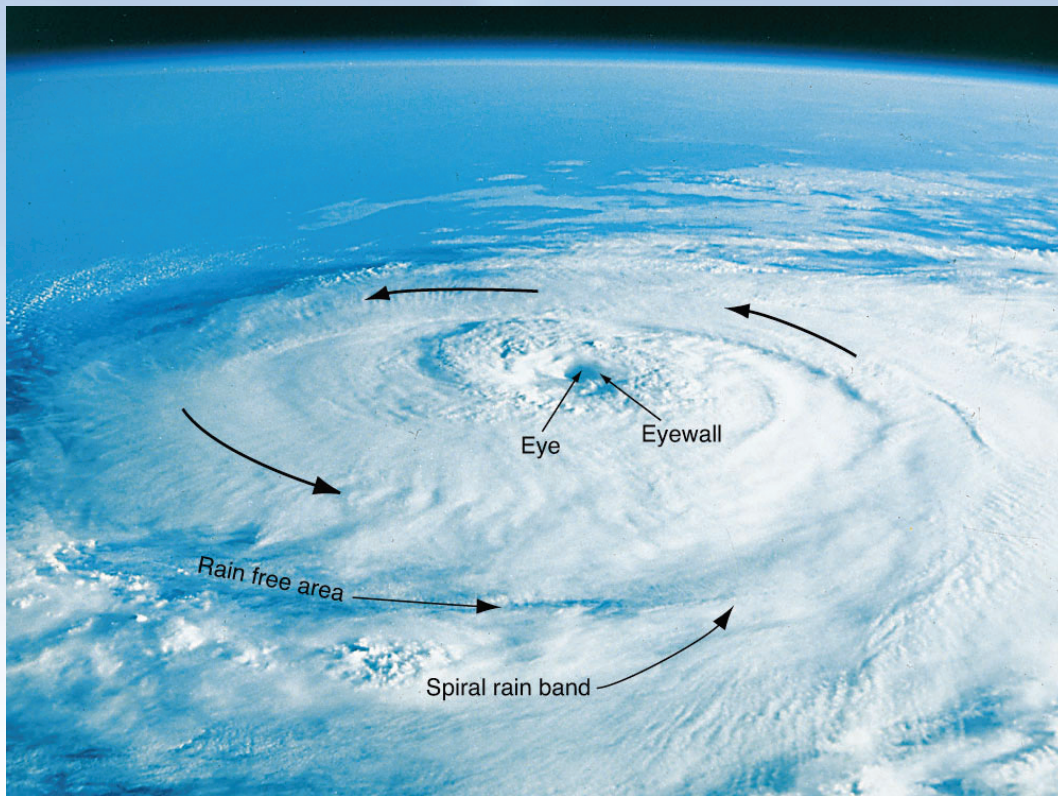
### Tropical Cyclones Diminish when they

- move over cold ocean water
- move over land
- interact with aloft winds or pressure systems

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## Anatomy of a Hurricane



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# Anatomy of a Hurricane

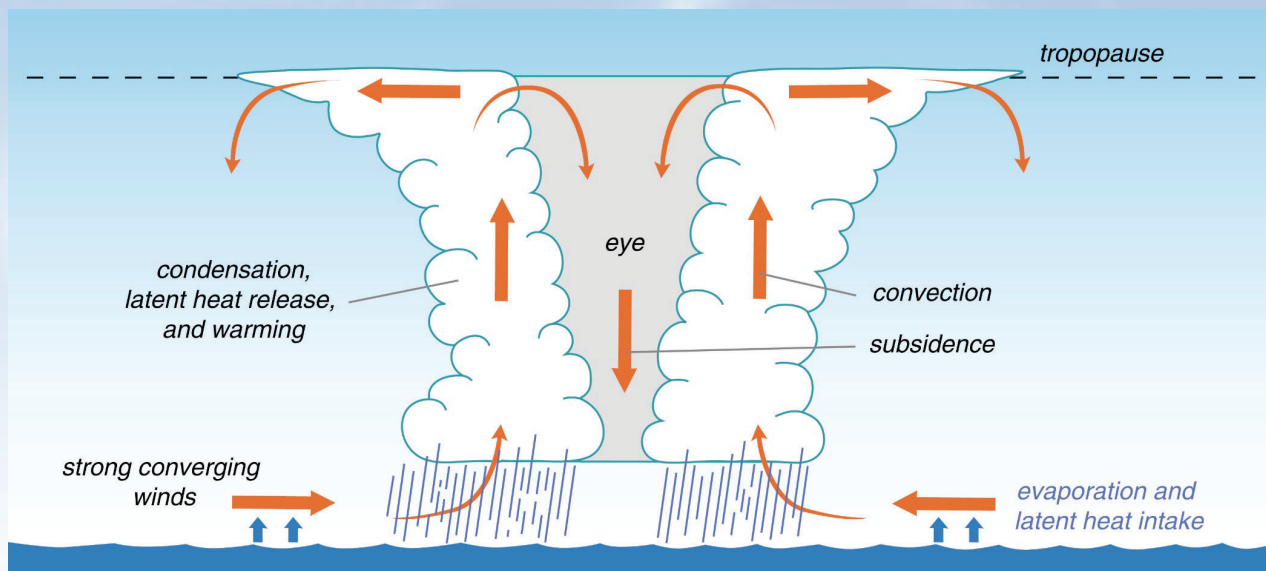
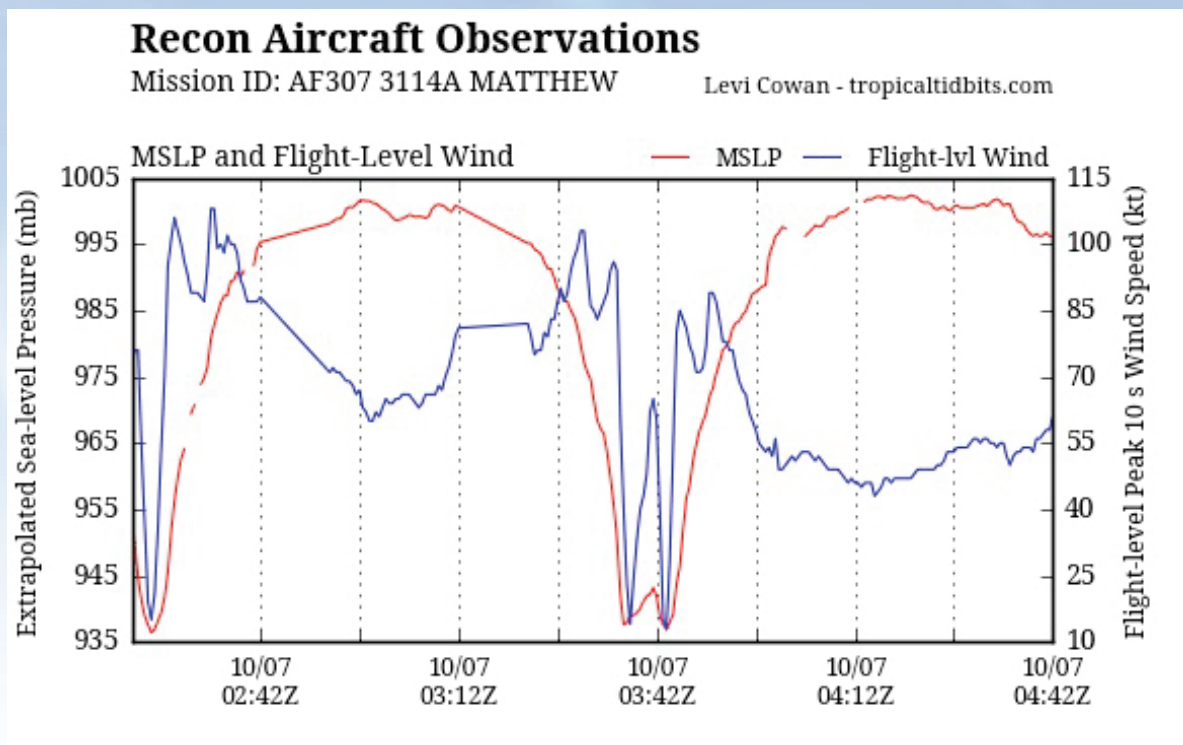


Fig 12-4 Weather A Concise Introduction

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# Anatomy of a Hurricane



Aircraft observations of Hurricane Matthew

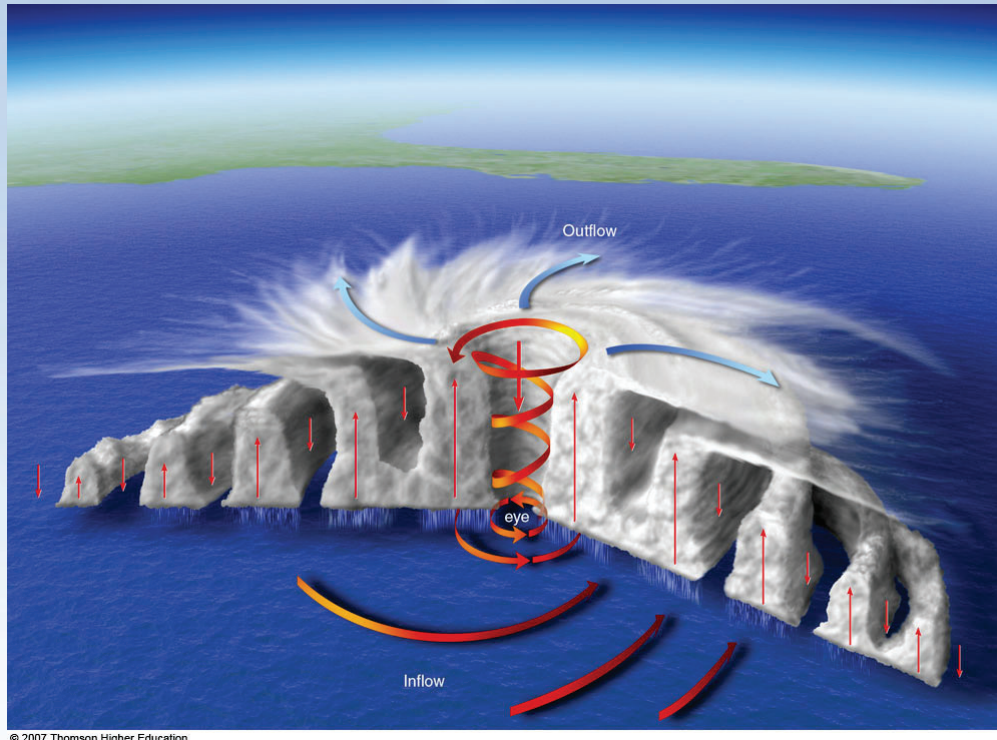
<https://www.wunderground.com/blog/JeffMasters/comment.html?entrynum=3470&page=5>

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# Anatomy of a Hurricane



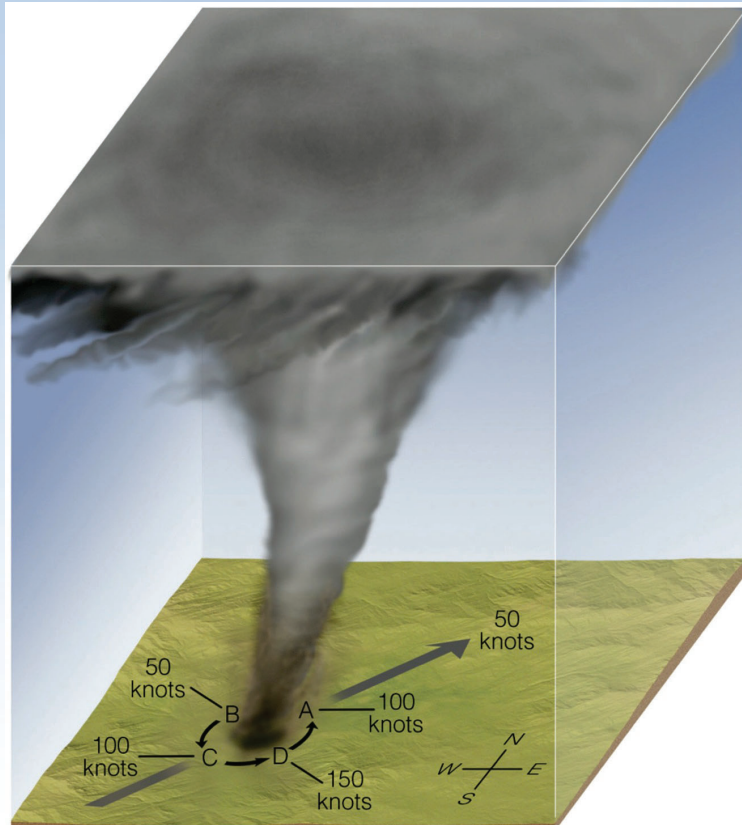
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# Tornadoes: Winds



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Wind damage is caused by

- 1) The surface speed of the tornado
- 2) The rotation speed of the tornado

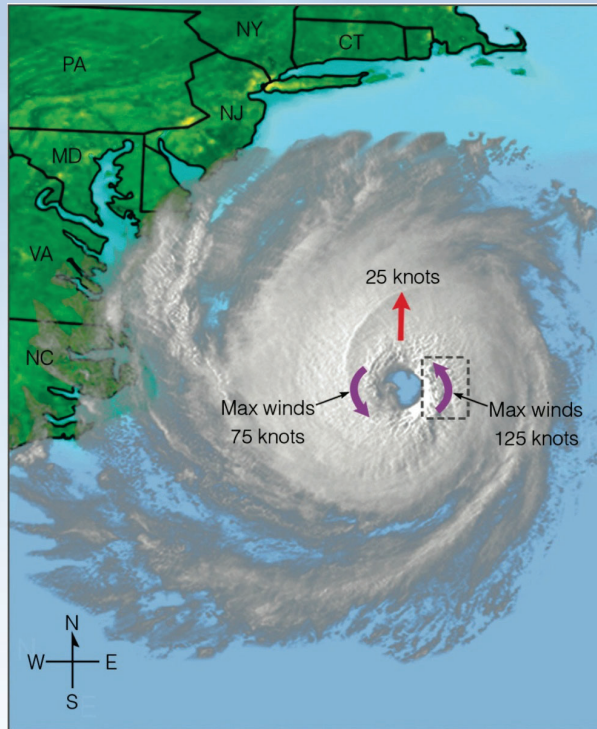
Fig 10-38 *Essentials of Meteorology*

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## Tropical Cyclone: Wind Damage

Winds on the left side blow in the opposite direction as the hurricane is moving. **Subtract the two speeds.**



Winds on the right side blow in the same direction as the hurricane is moving. **Add the two speeds together.**

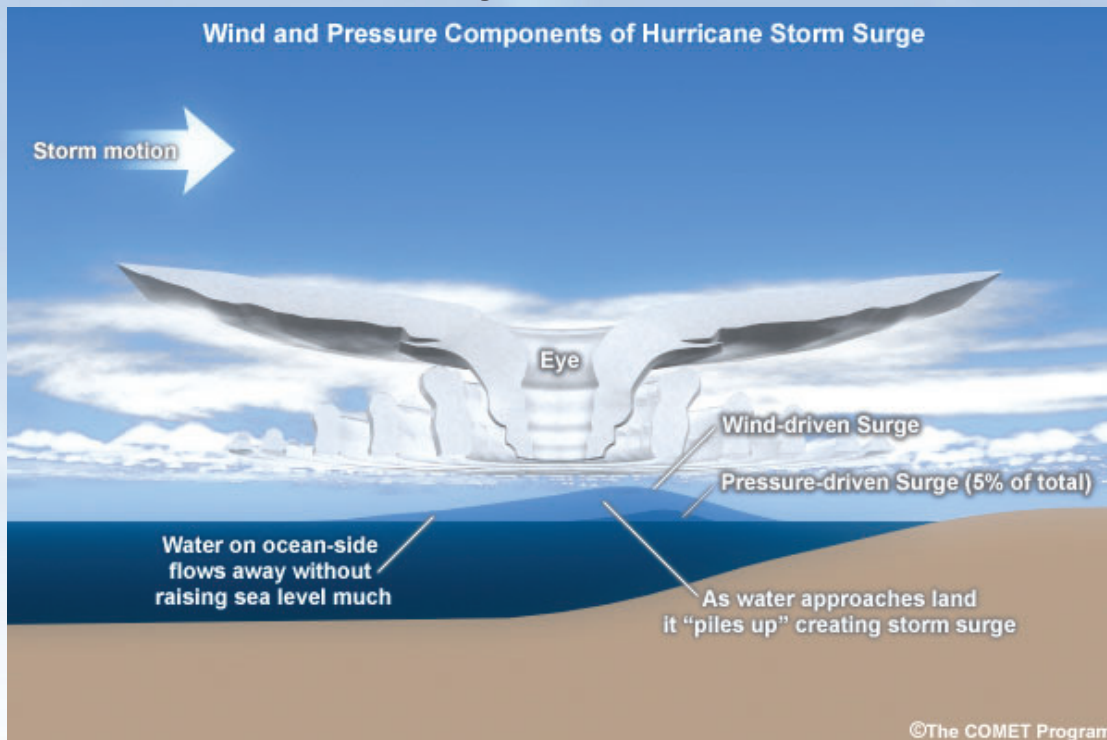
**Hurricane winds can be increased or reduced along path  
Can spin off tornadoes**

Fig 11-16 *Essentials of Meteorology*  
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## Tropical Cyclone: Seawater



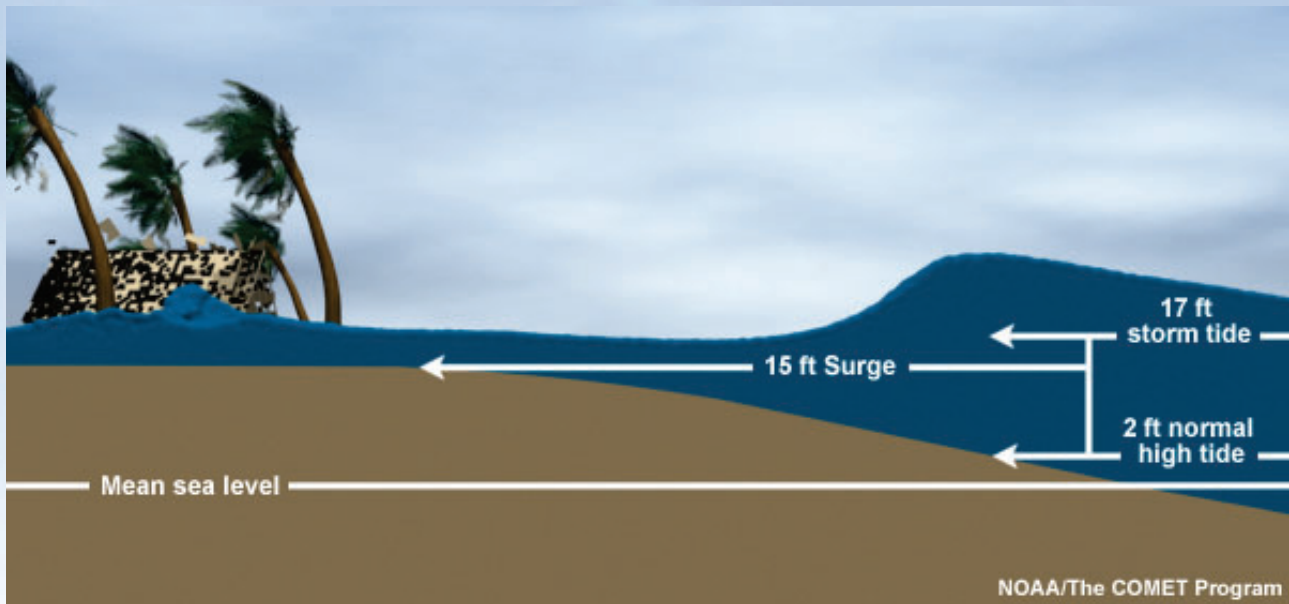
**Ocean water "piles up" in front of storm due to winds and low pressure**

<http://www.nhc.noaa.gov/surge/>

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# Tropical Cyclone: Seawater



**Storm surge can combine with normal tidal variations  
Surge can greatly erode beaches**

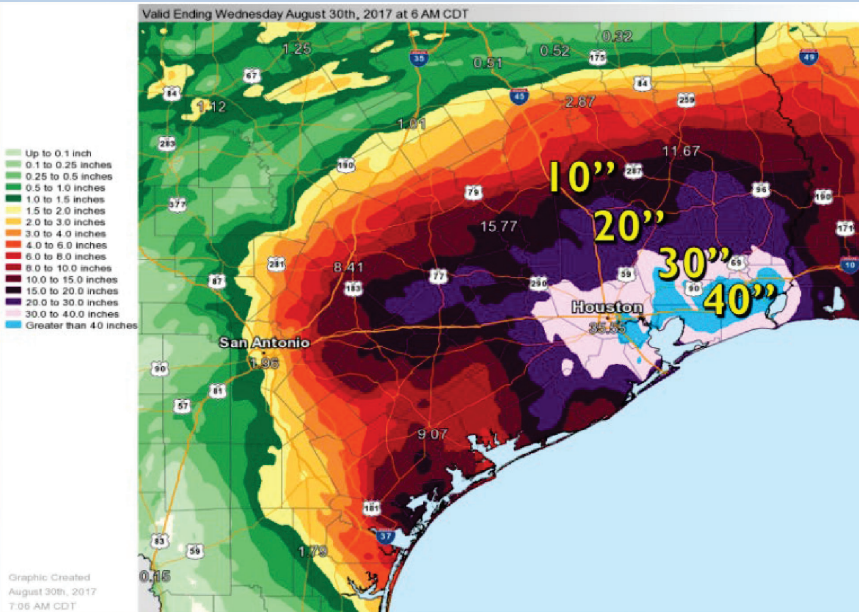
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<http://www.nhc.noaa.gov/surge/>

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# Tropical Cyclone: Rainfall



## 5 Day Point Rainfall Amounts in Inches

- Harvey continued to produce record breaking **rainfall totals of 45 to over 50 inches...** with continued rainfall
- **Cedar Bayou - 51.88**
- **Berry Bayou - 44.88**
- **League City - 49.84**
- **Mary's Creek - 49.80**
- **Goose Creek - 44.08**
- **Greens Bayou - 41.36**
- **Buffalo Bayou - 35.60**
- **Addicks Dam - 33.44**

Point rainfall data courtesy

Weather service had to add new colors to their figures

<https://www.weather.gov/hqx/hurricaneharvey>

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