# Formation Factors for Hurricanes

1. Sea Surface Temperatures (SSTs) > 27° and extending to some depth.

2. Location >5° away from the equator (usually 10°). Coriolis force is necessary for rotation.

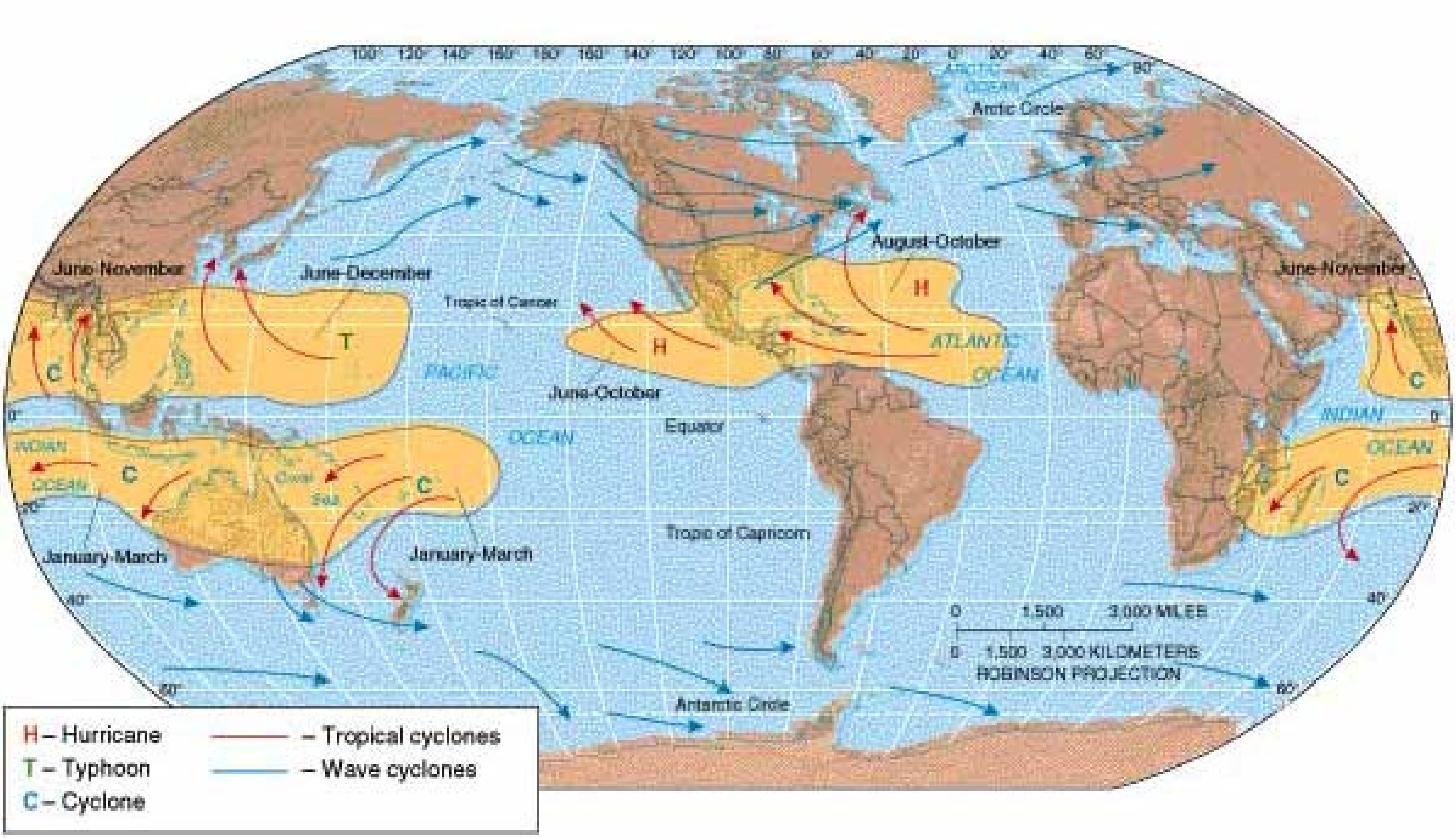
3. High relative humidity form the surface to the middle of the troposphere (a nearly saturated atmosphere).

4. Very weak vertical wind shear. No strong winds aloft; no ventilation.

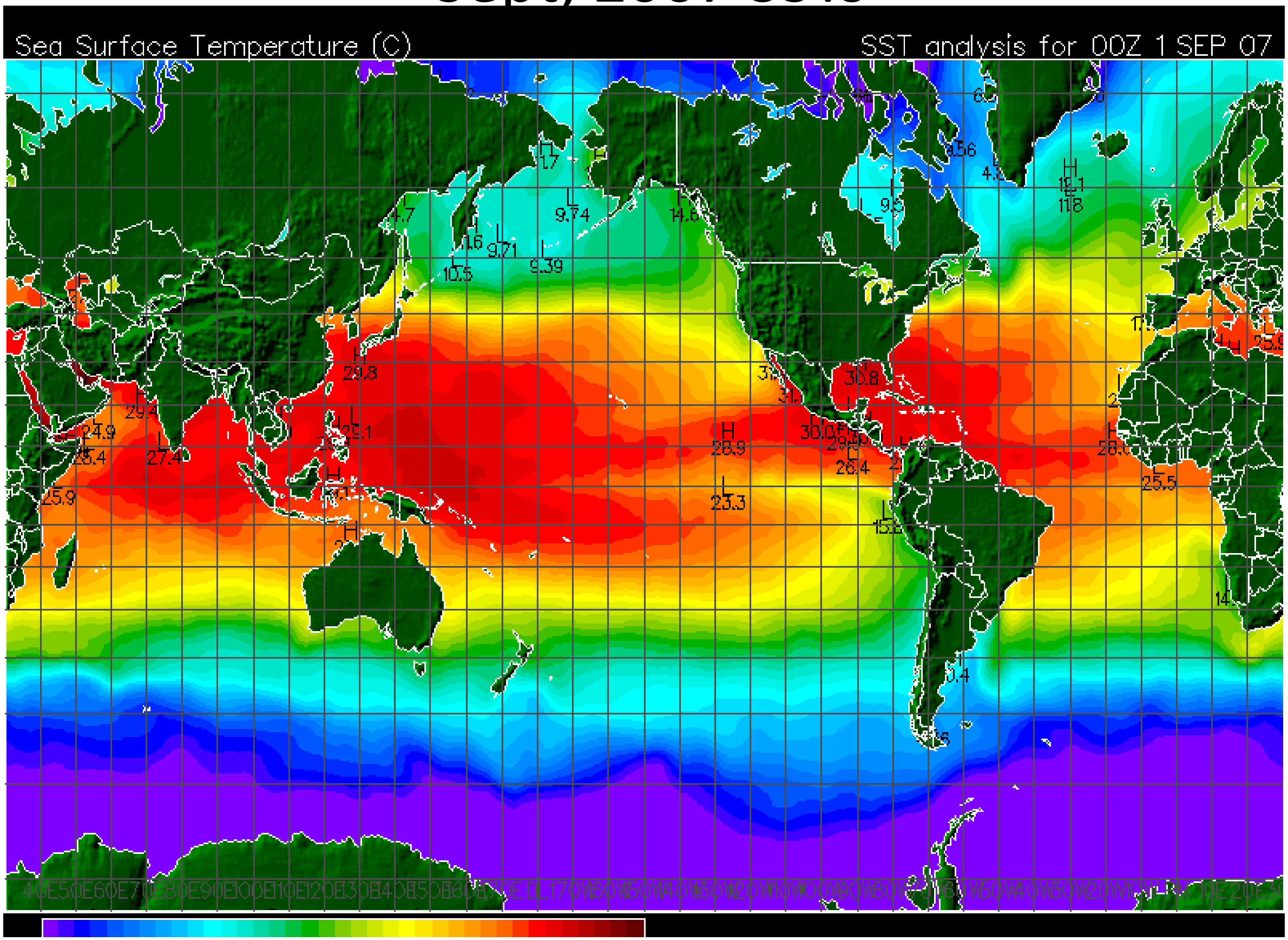
5. Easterly wave (trof in the trade winds) and associated vorticity helps to break down trade wind inversion.

6. A mid-latitude trof (of low pressure) to the north-west helps to destabilize the atmosphere.

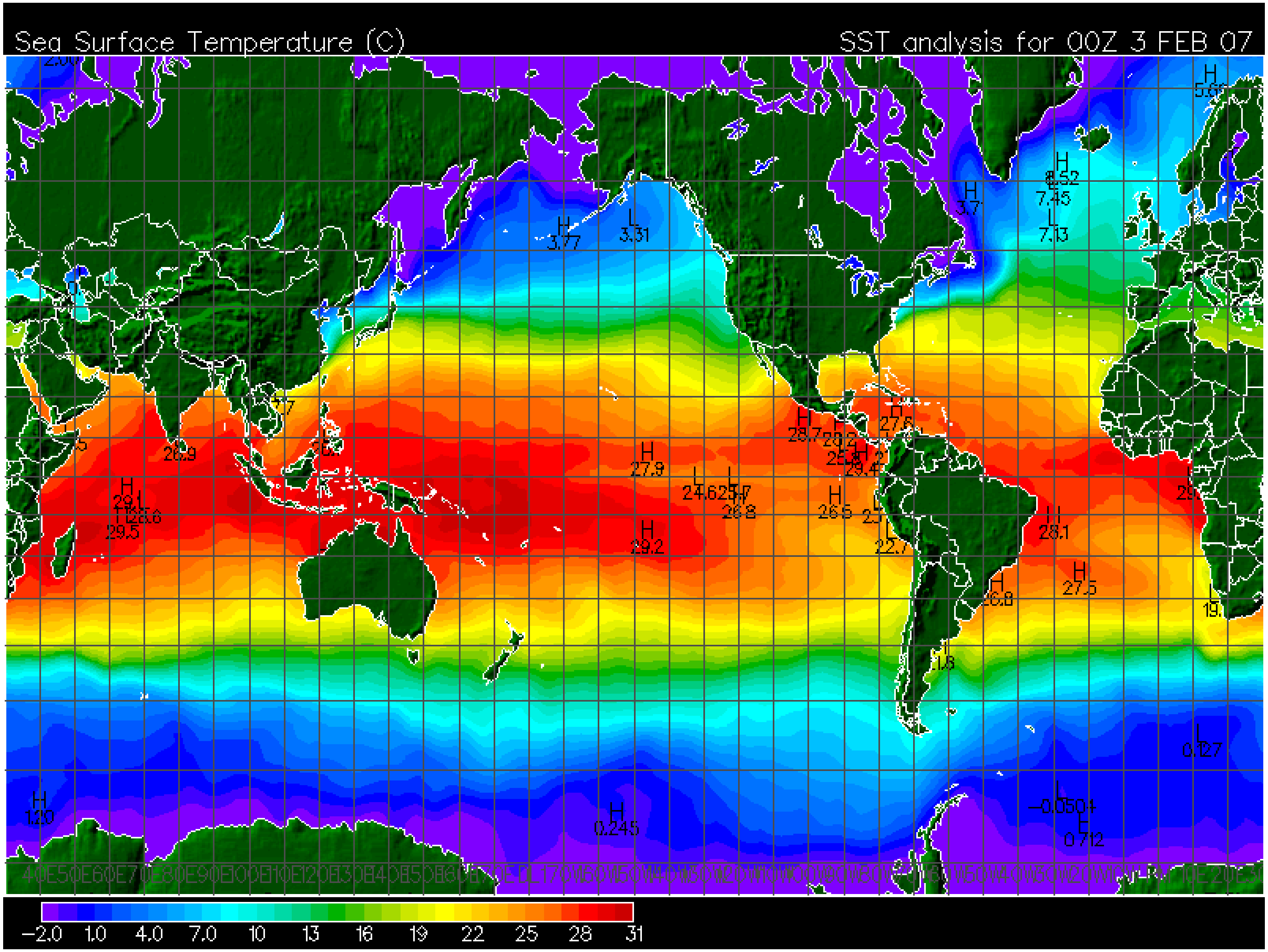
# But Must Be > 5° Latitude for Coriolis Force.



# Hurricane Formation Factor #2.
# Hurricanes Form in Oceans with SSTs > 27° C.
## Sept, 2007 SSTs

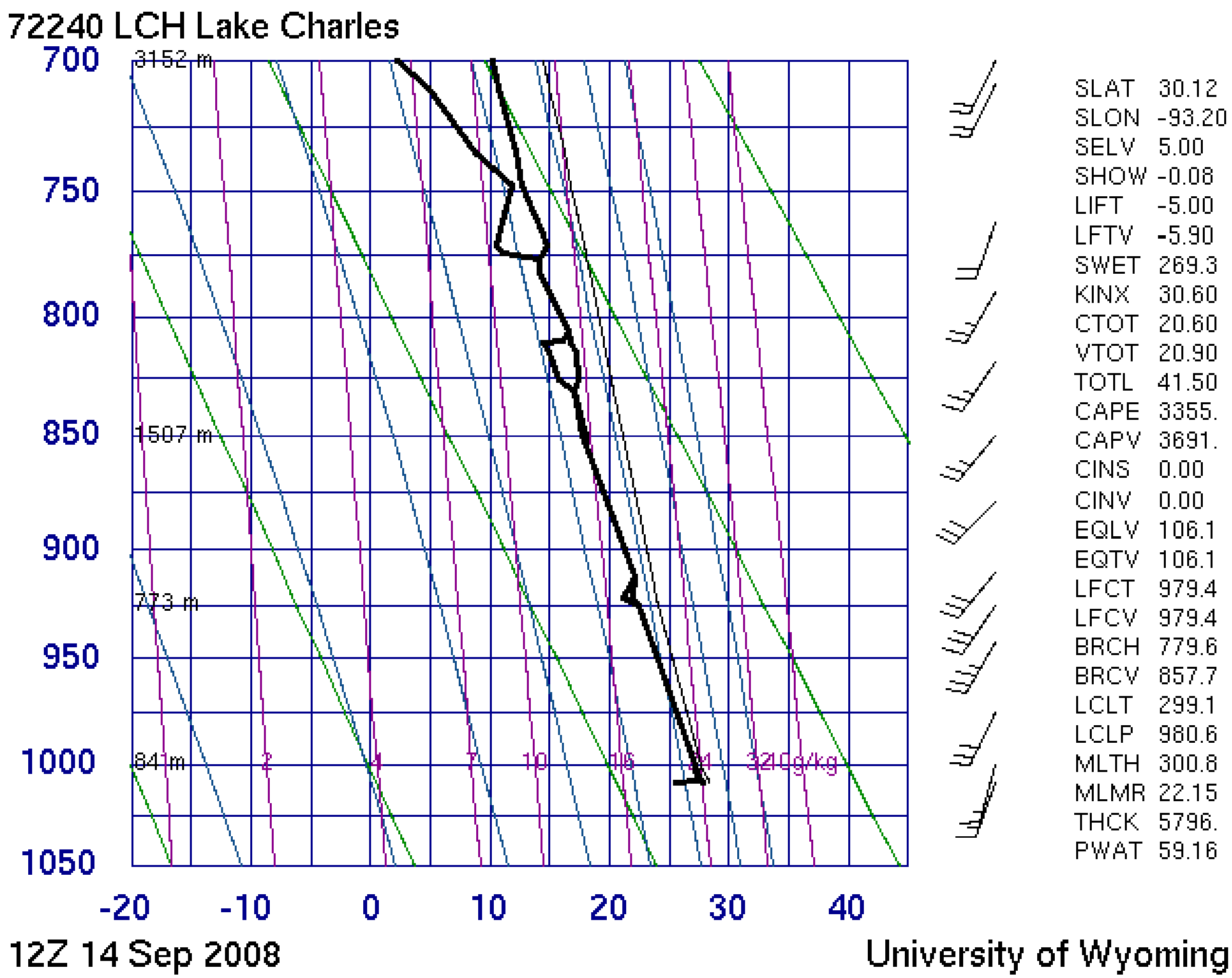


# February, 2007 SSTs

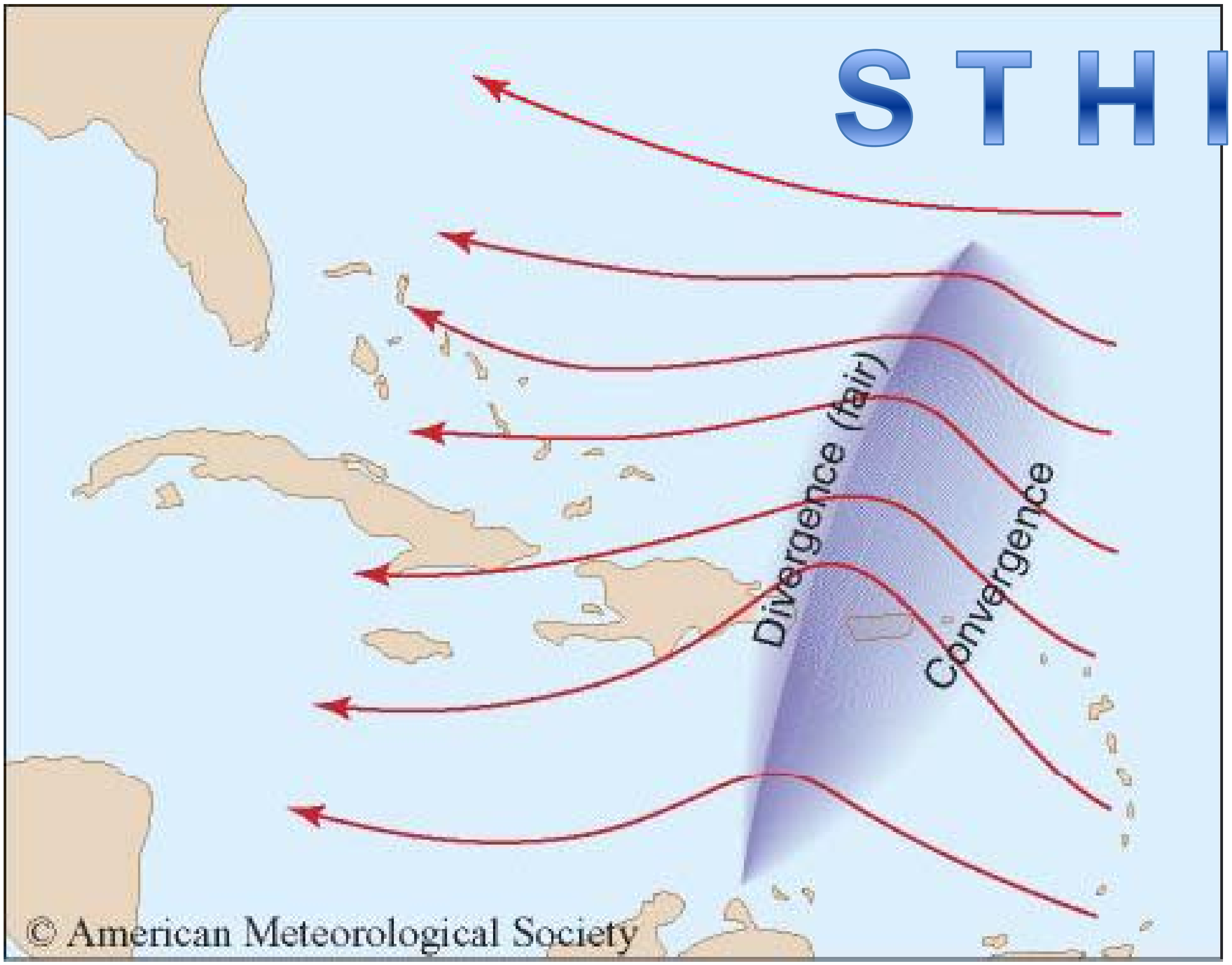


# Hurricane Formation Factor #3. The Atmosphere Must Be Nearly Saturated from the Surface to Middle Troposphere

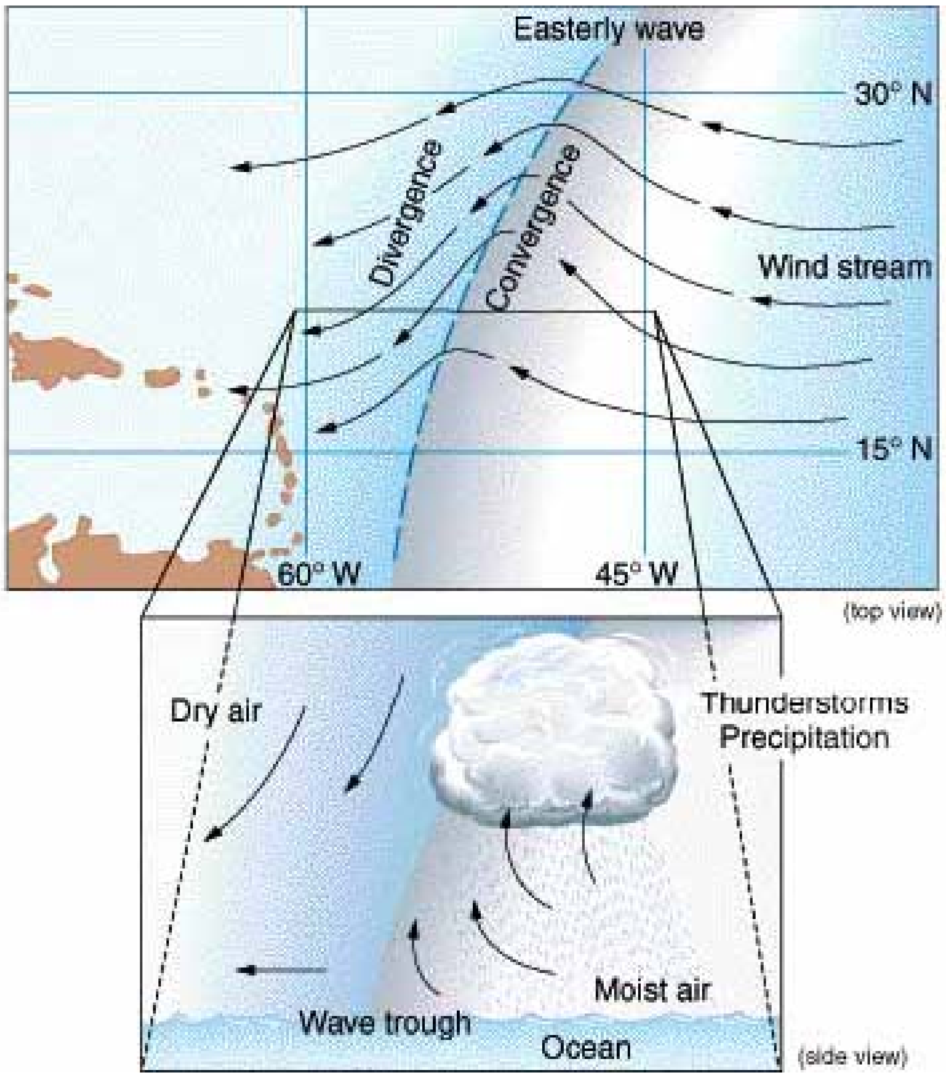
#4 Also, Requires Very Week Vertical Wind Shear. No Strong Winds Aloft Means No Ventilation



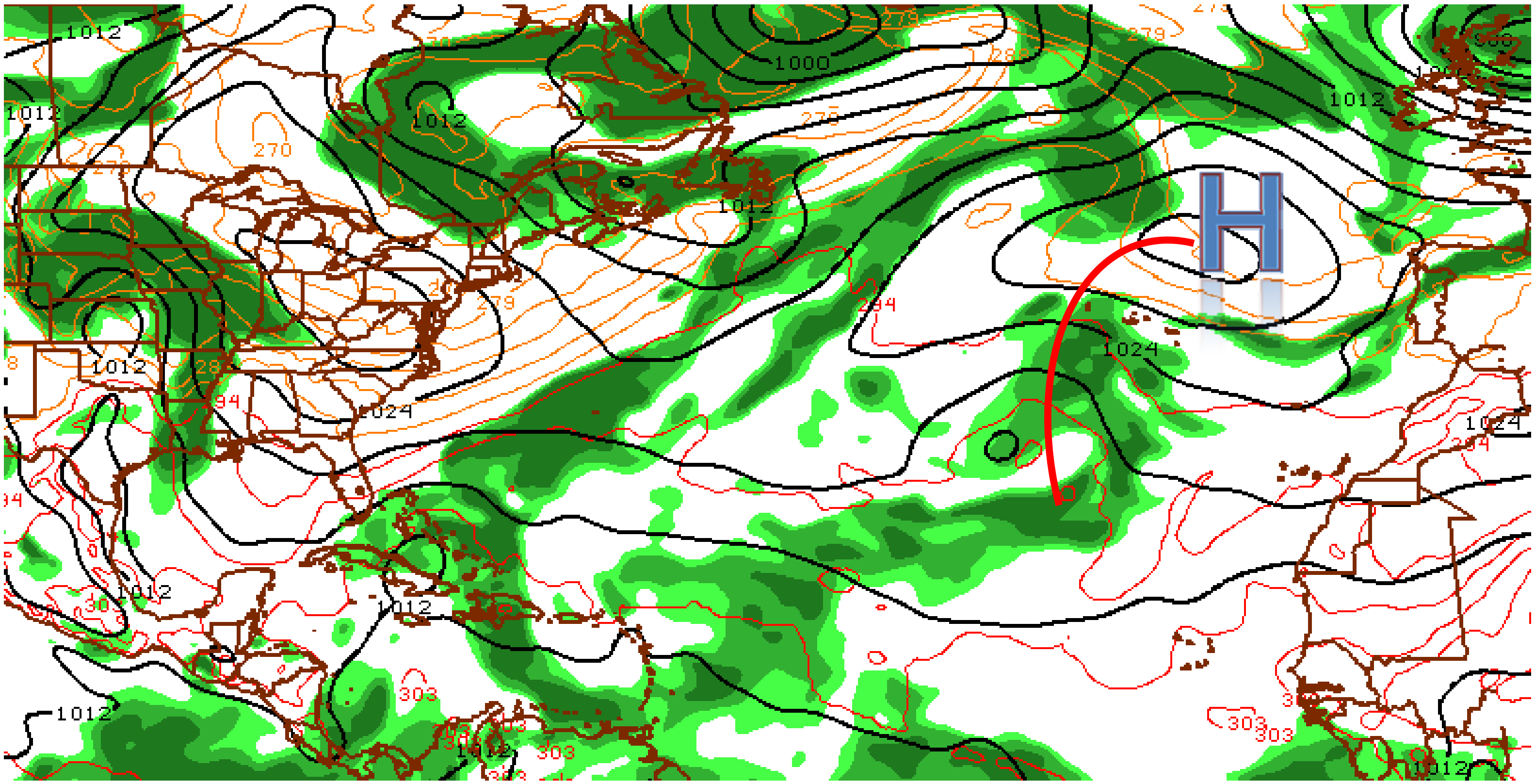
# Hurricane Formation Factor #5. Easterly Wave (trof) in the Trade Winds Which Are the Outflow of Air From an STHI.



# Easterly Wave Induces Surface Convergence to the East of Main Axis of Trof

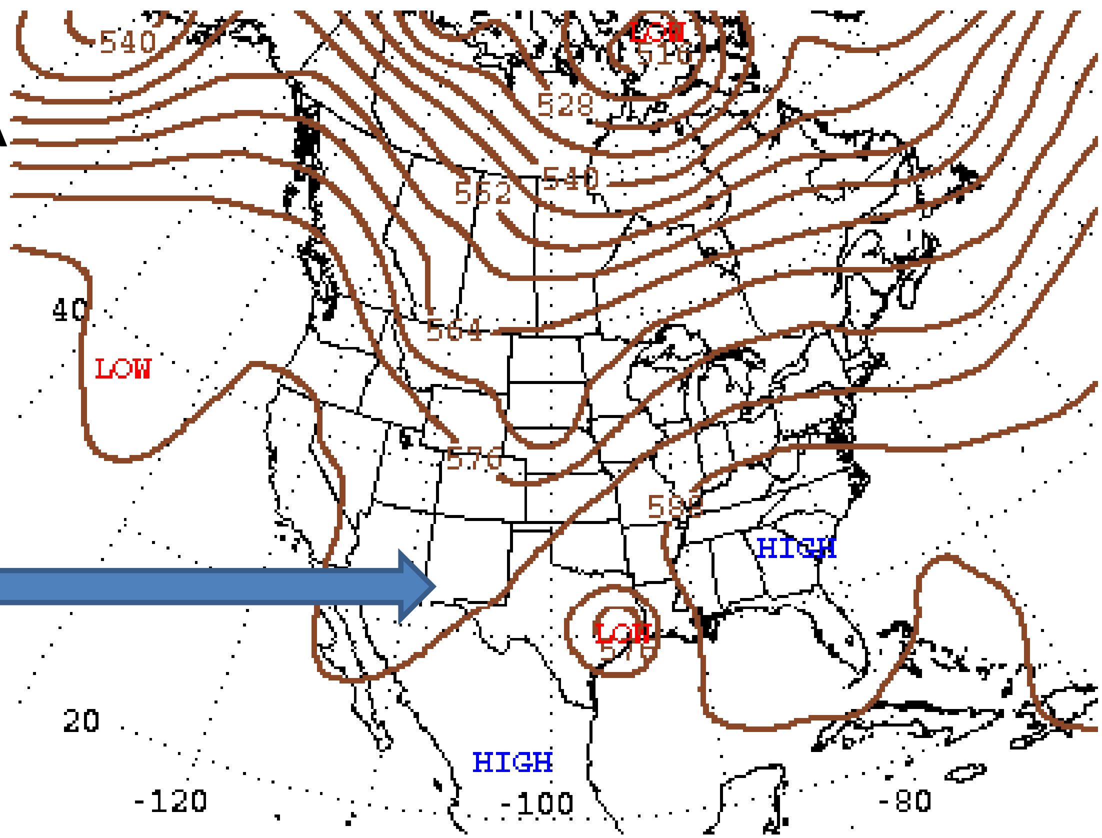


# Easterly Wave on Southern Edge of STHI, Red Line Shows Main Axis of this Trof.



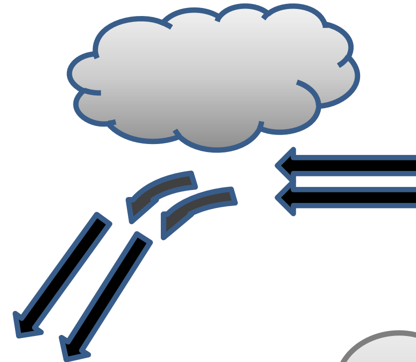
# Hurricane Formation Factor #6. Trof in Westerlies Is Located to North and West. Hurricane Ike at Landfall.

Late in the Season, A Trof in the Mid-Latitude Westerlies (to the north-west) Can Help Destabilize the Atmosphere Further South




500-Millibar Height Contour at 7:00 A.M. E.S.T.

# Stages in Hurricane Development



Tropical Disturbance

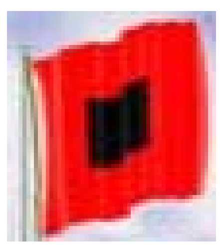
Cloudy, light winds, no closed isobars

Tropical Depression

At least one closed isobar, winds of 23-38 mph.

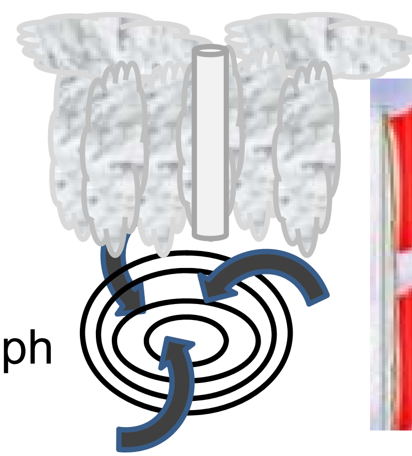
Tropical Storm

More closed isobars, more rotation, gale force winds of 39-74 mph.



Hurricane

More closed isobars, more rotation, winds of > 74 mph



# Wind Damage

- 35 mph
- 50 – 65 mph
- 65 – 84 mph
- 85 – 104 mph
- 105 – 130 mph

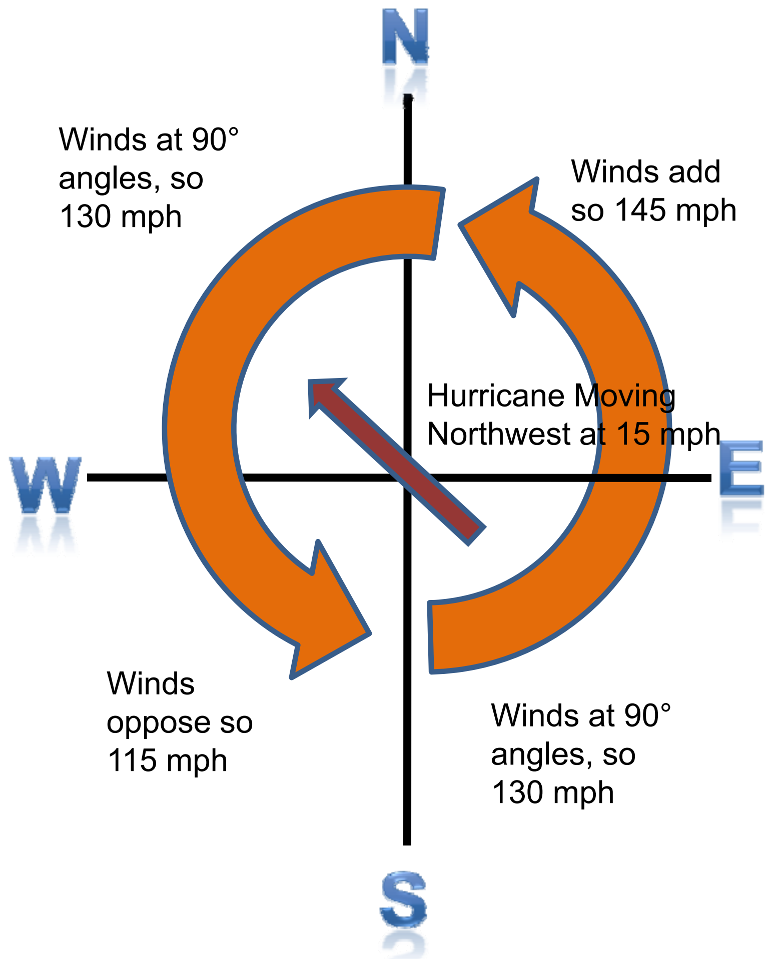
- Little Damage
- Shingles Blown Off
- Windows and Boards
- Structural Framing
- Major Destruction, Some Total

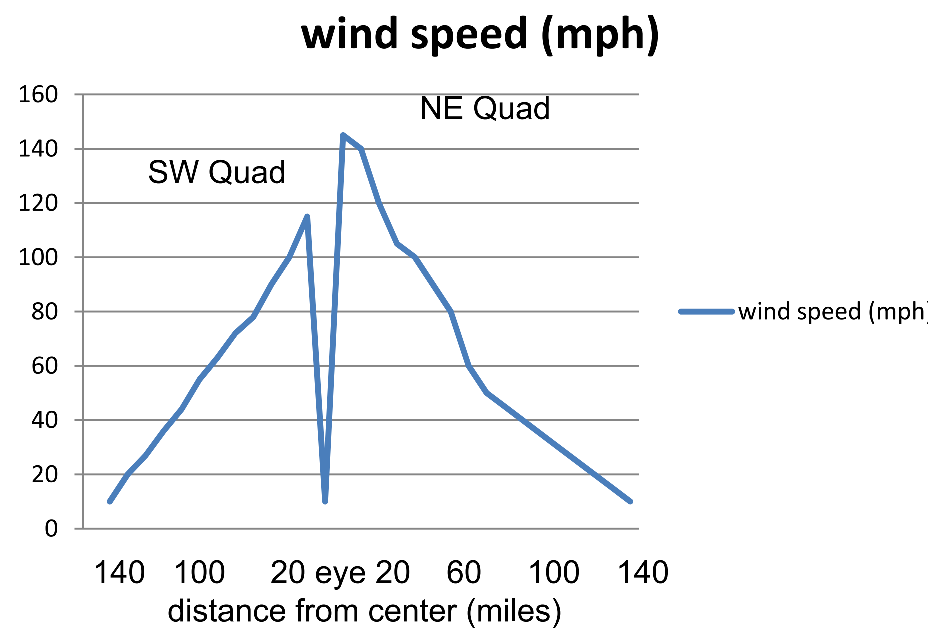
# Dissipation Factors

- At Landfall, 100% of Force
- 25 Miles Inland, 85%
- 50 Miles Inland, 75%
- 100 Miles Inland, 60%
- 150 Mile Inland, 50%

# Translation Speed Refers to the Wind Speed in Different Sectors of the Storm

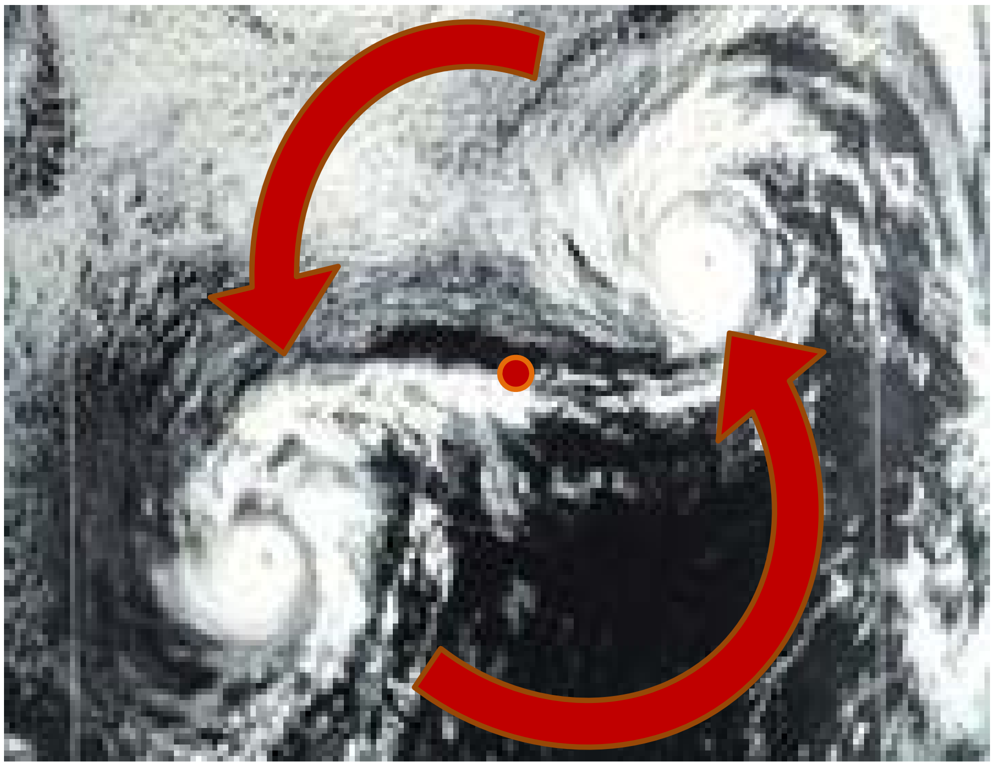
The wind speed in each sector is determined by the relationship between direction and speed of rotating winds (130 mph) and movement of storm across the ocean (15 mph).



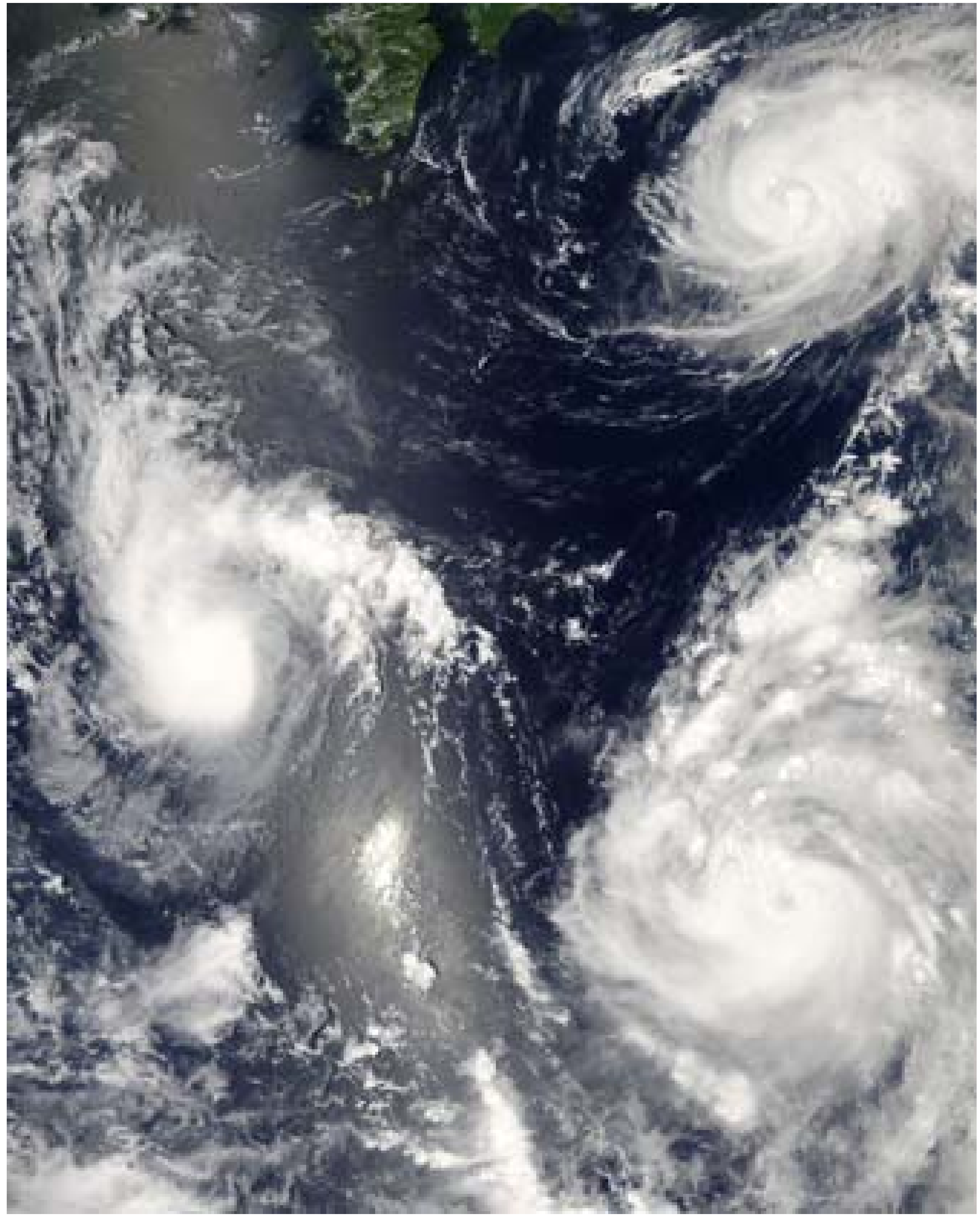
# The Fujiwara Effect.

## Twin hurricanes Ione (left) and Kirsten (right) pinwheeling about the eastern Pacific (1974).



When hurricanes are close together, they interact in a kind of dance. They both revolve around a central pivot point, but the larger one revolves around an inner path while the smaller one takes a path farther away from the center. These two are equal.

This Famous Image Shows Three Typhoons Operating in the Same Region of the Pacific at the Same Time. Dr. Fujiwara Would be Proud.



# Sources of Hurricane Damages

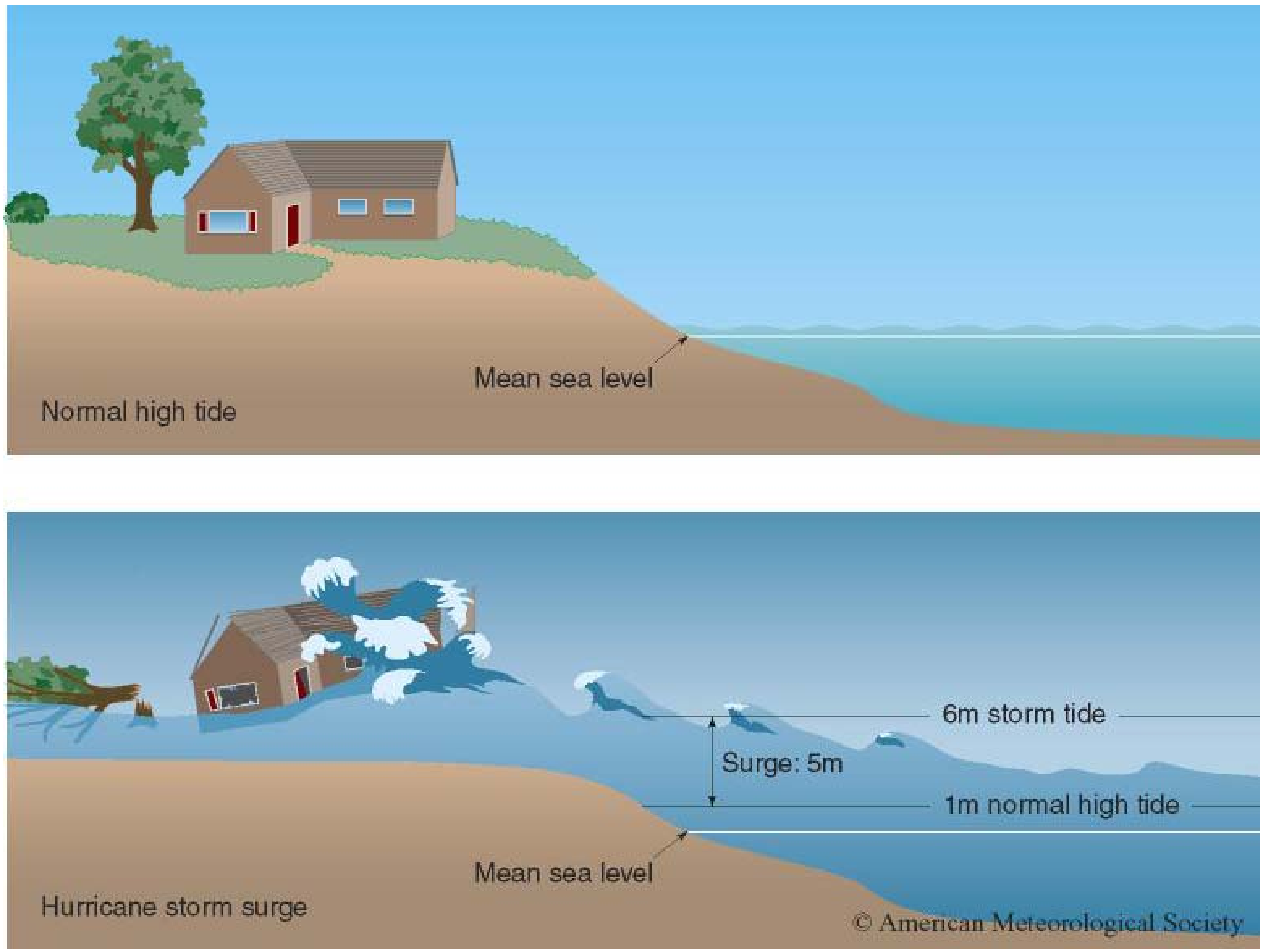
Rain

Flood

Wind

Tornadoes – Spin up vorticies

# The Storm Surge Is the Rise in Sea Level. Wave Action Occurs on Top of That.

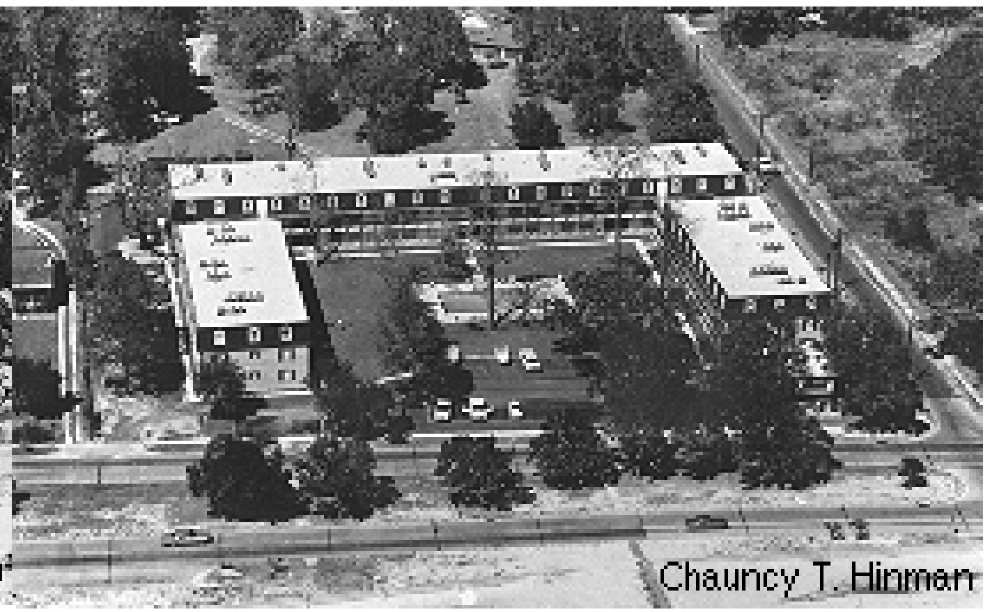


# Height of Storm Surge

While the high wind speeds in hurricanes cause a lot of damage, water is actually the more destructive force. The amount of damage that a hurricane does is directly related to the height of the storm surge.

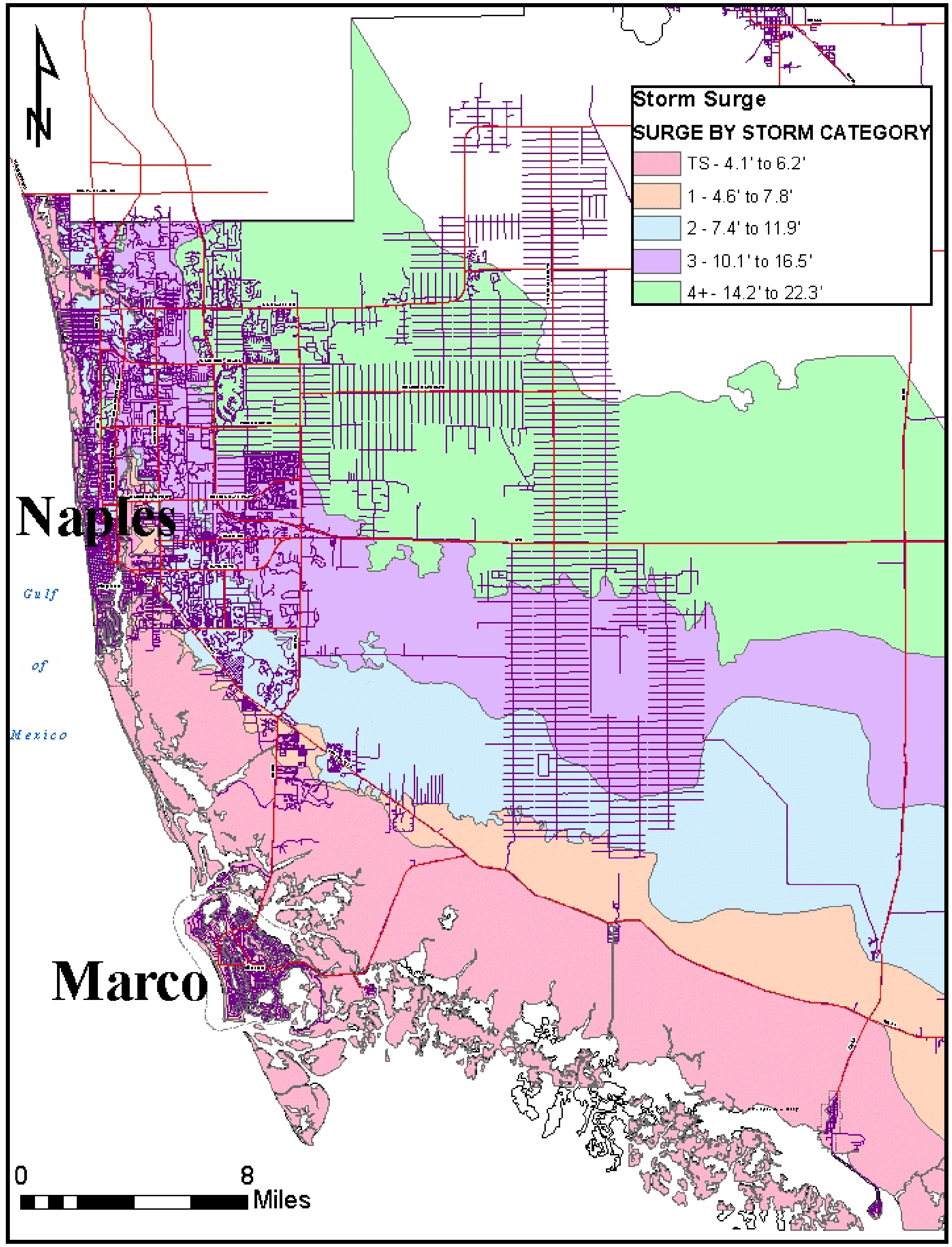
1. Wind speed. The faster the winds, the higher the waves.
2. Pressure. The lower the pressure, the faster the winds. The lower the pressure, the higher the rise in sea level underneath the area of low pressure. This is sometimes called the "dome" and there is wave action on top of the dome.
3. Fetch is the distance that the winds move across the ocean, generally the longer the fetch, the higher the waves.
4. Shoreline configuration. Some actually funnel the storm surge into a smaller area raising the height of the storm surge locally.
5. Slope or gradient of the coast. Is the gradient very slight or is there an abrupt dropoff of the bottom near the coast?
6. Tides and timing. If the hurricane makes landfall coincident with the highest tides of the day, the storm surge will be higher.

# Richelieu Apartments Before and After Camille.  One Person Actually Survived

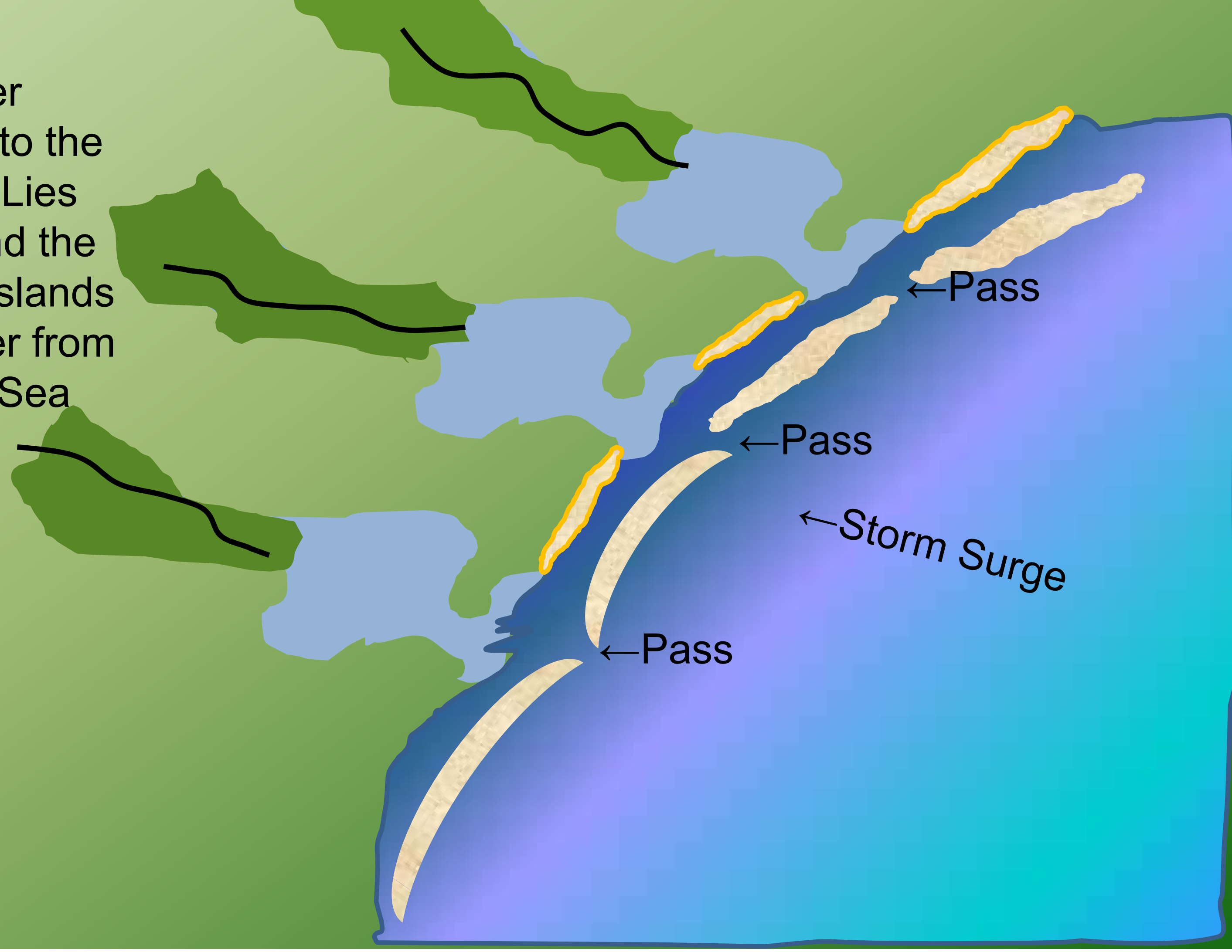
The SLOSH Model IS Used to Predict Flooding From Each Stage of Hurricane Severity.

The Map is for the Naples Florida Area



# Physiographic Layout of Texas Coast.
# East Texas Is a Series of Low Coastal Plains Bisected by Rivers that End in Brackish Estuaries

A Series of Low Barrier Islands Runs Parallel to the Coastline. A Lagoon Lies between the Island and the Coast. Between the Islands is a Pass Where Water from the Rivers Enters the Sea



# Hurricane Computer Model, Really Applies to Any Weather Computer Model

- Equations of Motion = Pressure gradient force, Coriolis, friction.
- Equations of Thermodynamics = How air changes temp.
- Water Vapor Content
- Conservation of Mass Equations
- Hydrostatic Equation = Pressure is related to total mass of air above
- Equation of State = K * Density * Temp
- Solve for 6 variables for a point (approximating the station model).
  - Horizontal Velocity and Direction
  - Pressure
  - Temperature
  - Density (Mass/Volume)
  - Water Vapor Content
  - Vertical Velocity

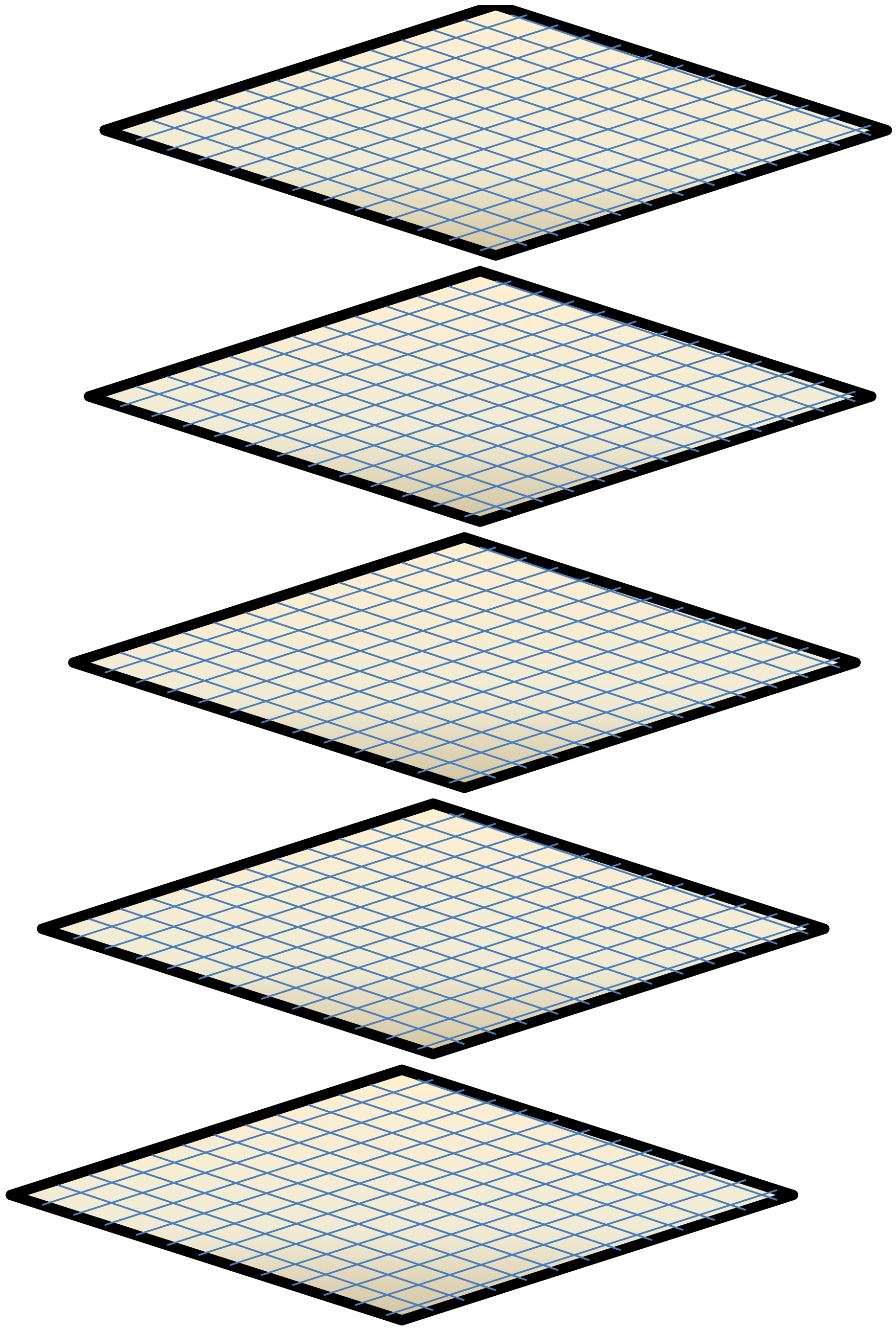
# Model Output Showed Positive Feedback Between T-Storms and Hurricane

- Latent heat warms the air aloft, pressure falls at surface, air accelerates towards center, whole hurricane system spins faster.
- But, air is ‘gobbled up’ by T-storms, and air is “packed” so tight it creates a finite radius with the eye inside.  Air descends into this core of low pressure from above.
- Speed of winds is governed by the Law of Conservation of Angular Momentum

# The Law of Conservation of Angular Momentum Is Illustrated by the Weight on the End of String when Revolving

- If the string is let out (longer) the weight revolves more slowly. If the string is shortened, the weight revolves faster. In each case the angular momentum is the same because it is the product of mass X velocity.
- In a hurricane, this law governs wind speed at a given distance from the eye (center).
- 100 miles X 10 mph = 1000
- 50 miles X 20 mph = 1000
- 20 miles X 50 mph = 1000
- 10 miles X 100 mph = 1000

# Model Output Is by Grid Cell and Layers Often 1 km Intervals



3 km

2 km

1 km

Surface