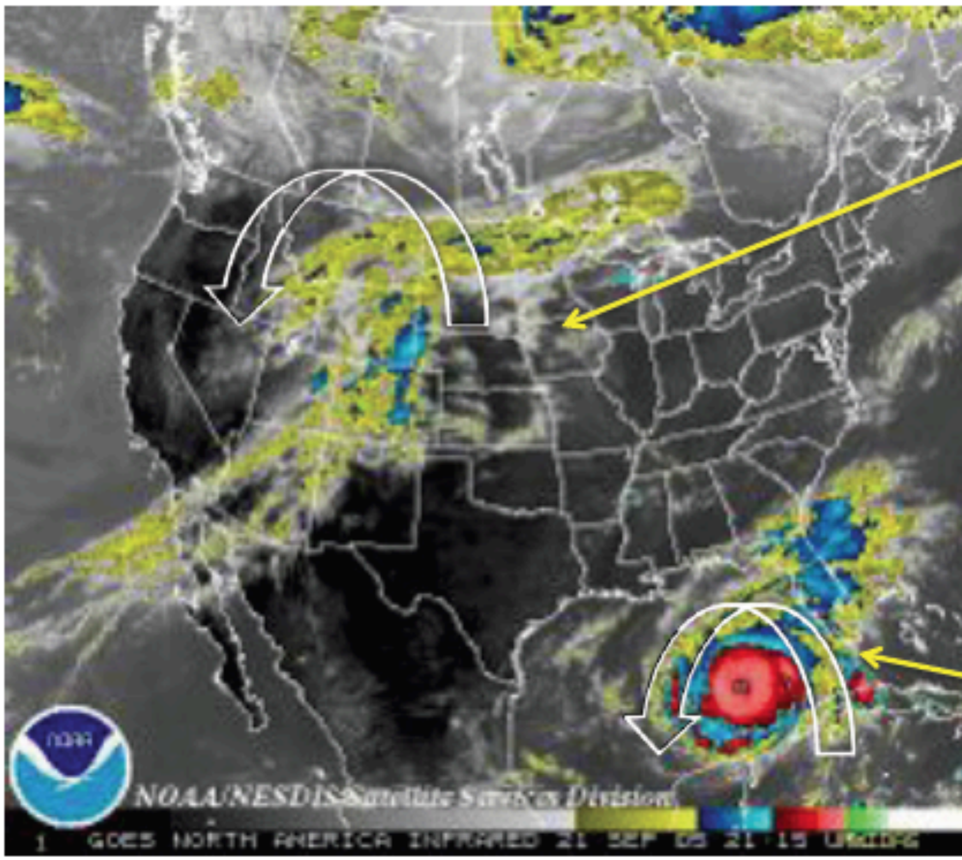
ATMOSPHERIC STORMS:

(1) Extratropical Cyclones (e.g., Nor'Easters)

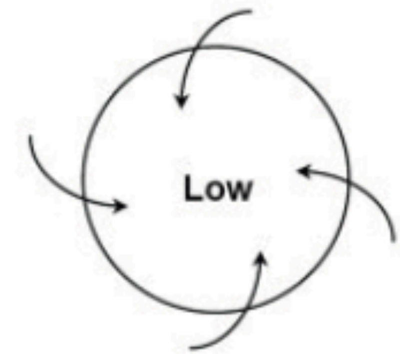
(2) Tropical Cyclones (e.g., Hurricanes)

*storms are low pressure systems, hence cyclonic.



Extratropical Cyclone

Tropical Cyclone (Hurricane Rita)



9/21/2005

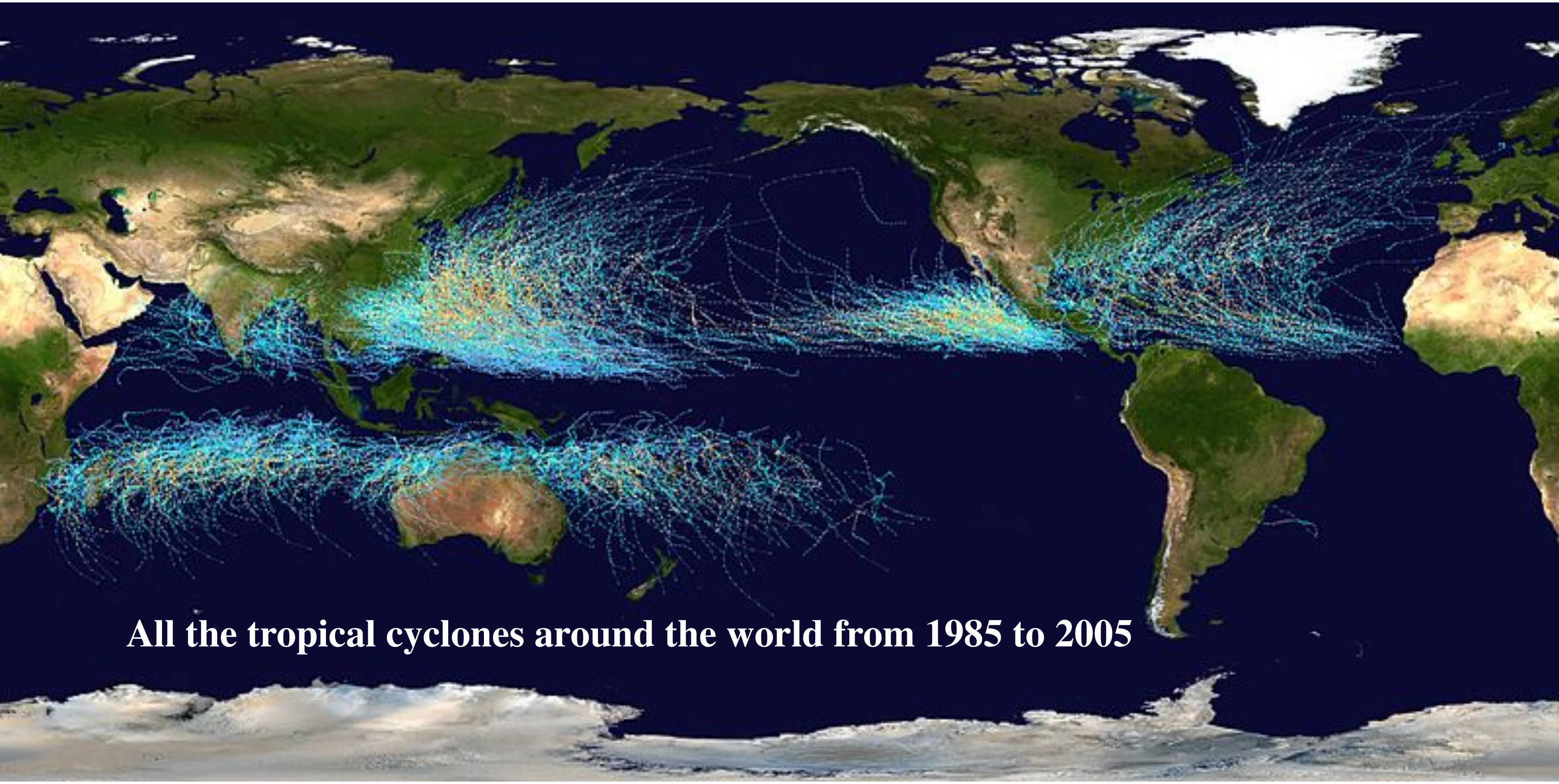
WALLACE AND HOBBS CHAPTER 8

LESSON GOALS:

- Understand what a TC is.
- Assess how TC and ETC are similar and different.

- Synthesize storm circulation and components.
- Explain formation mechanisms and link them to the storm's energy sources and behavior.

Tropical Cyclone Locations and Terminology



All cyclonic storms that form in the tropics are tropical cyclones.

Special Names

N Atlantic and Eastern N. Pacific: Hurricanes

Western N. Pacific: Typhoons

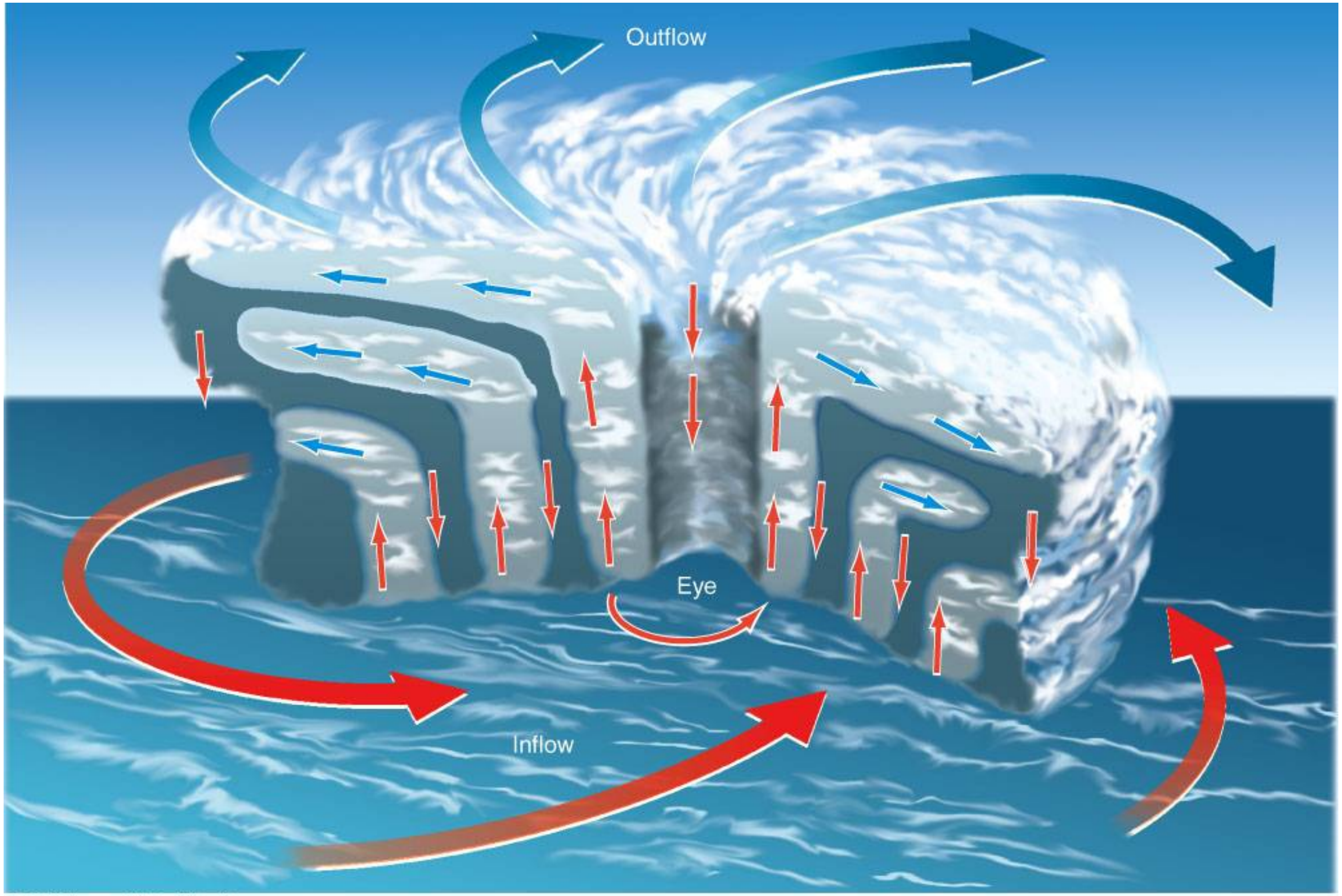
Ingredients for a tropical cyclone

- Warm SST, greater than 26˚ C (what does SST stand for?)
- Warm temperatures and high RH between 0 and 3 km.
- Light winds throughout the troposphere (tricky!!!); Need enough wind to create weak low-level shear, but strong upper-level shear is no good.
- Need a trigger for vertical motion – convections; or a specific lateral wave
- Typically, formation occurs between 5˚ and 20˚, why not closer to equator?

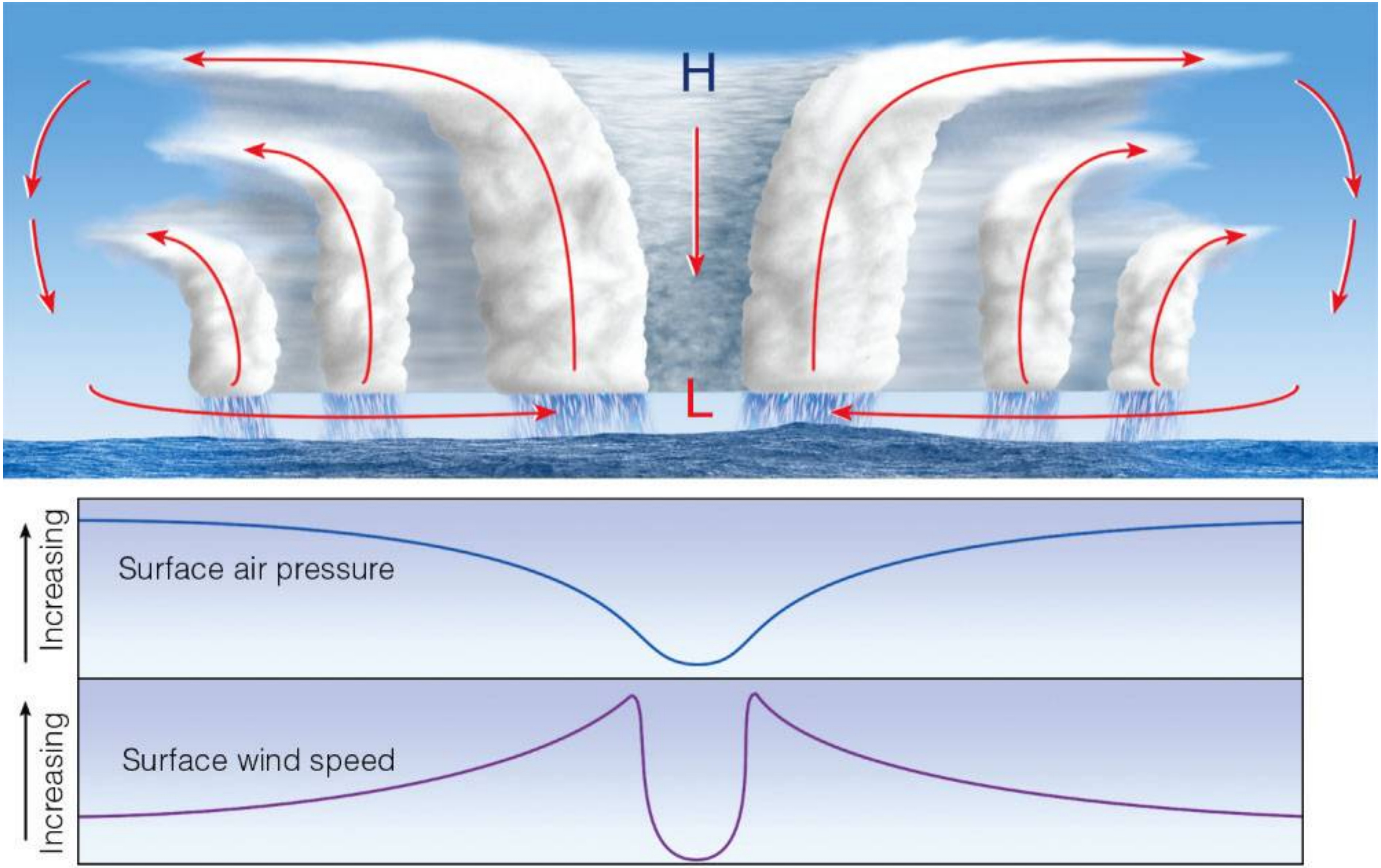
Factors inhibiting formation:

- Cold SST
- Strong trade winds with subsidence
- Strong upper-level winds

SCHEMATIC OF CIRCULATION WITHIN A WELL-DEVELOPED TROPICAL CYCLONE



SCHEMATIC OF CIRCULATION WITHIN A WELL-DEVELOPED TROPICAL CYCLONE



SUMMARY OF SCHEMATICS

- Converging, cyclonic air motion at surface
- Surface winds are strongest in eyewall
- Diverging, anticyclonic motion at tropopause level

- Rising motion occurs in the eyewall

- Subsidence on outer edge of storm rain bands

- Sinking motion in the eye

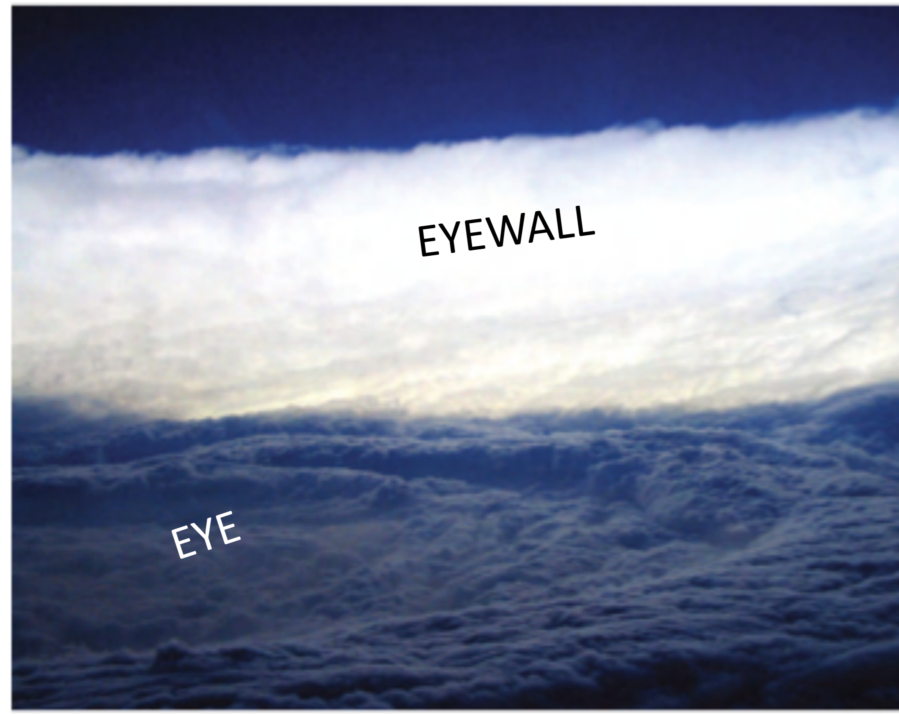
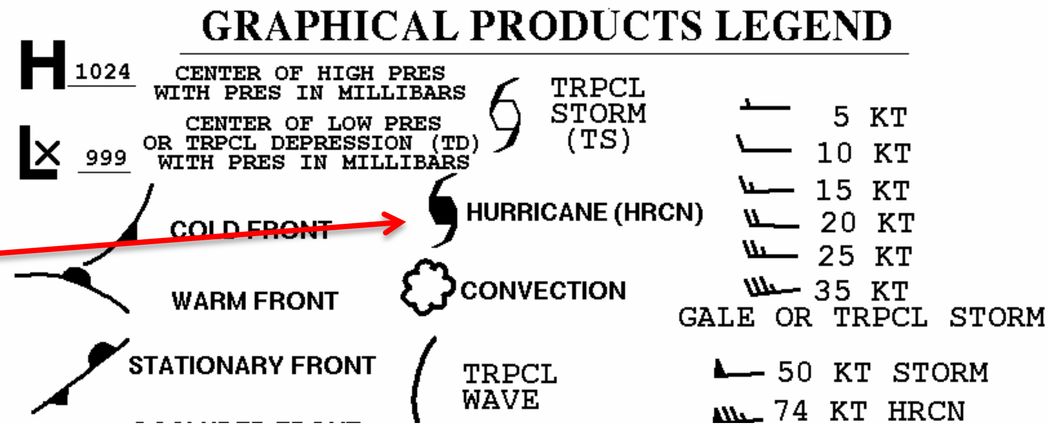


Fig. 8.77 The eye of Category-5 Hurricane Katrina late

Positive Feedback to Enhance Tropical Cyclones

1. Surface fluxes of heat and moisture from warm SST invigorate the column of air
2. Intense latent heating within the column generates high pressure; this leads to divergence aloft and lowers the pressure at the surface.
3. Lower surface pressure near the center increases the pressure gradient around the storm center- creating stronger surface winds
4. Stronger surface winds create a choppy oceans which increases the surface friction
5. Increased surface friction leads to more surface convergence into the center of the storm.
6. This feeds back on 1..

WEATHER CHARTS AND STORM RANKING



Subject: D1) How are Atlantic hurricanes ranked?

Contributed by Chris Landsea

The USA utilizes the Saffir-Simpson hurricane intensity scale *(Simpson and Riehl 1981)* for the Atlantic and Northeast Pacific basins to give an estimate of the potential flooding and damage to property given a hurricane's estimated intensity:

Saffir-Simpson Scale

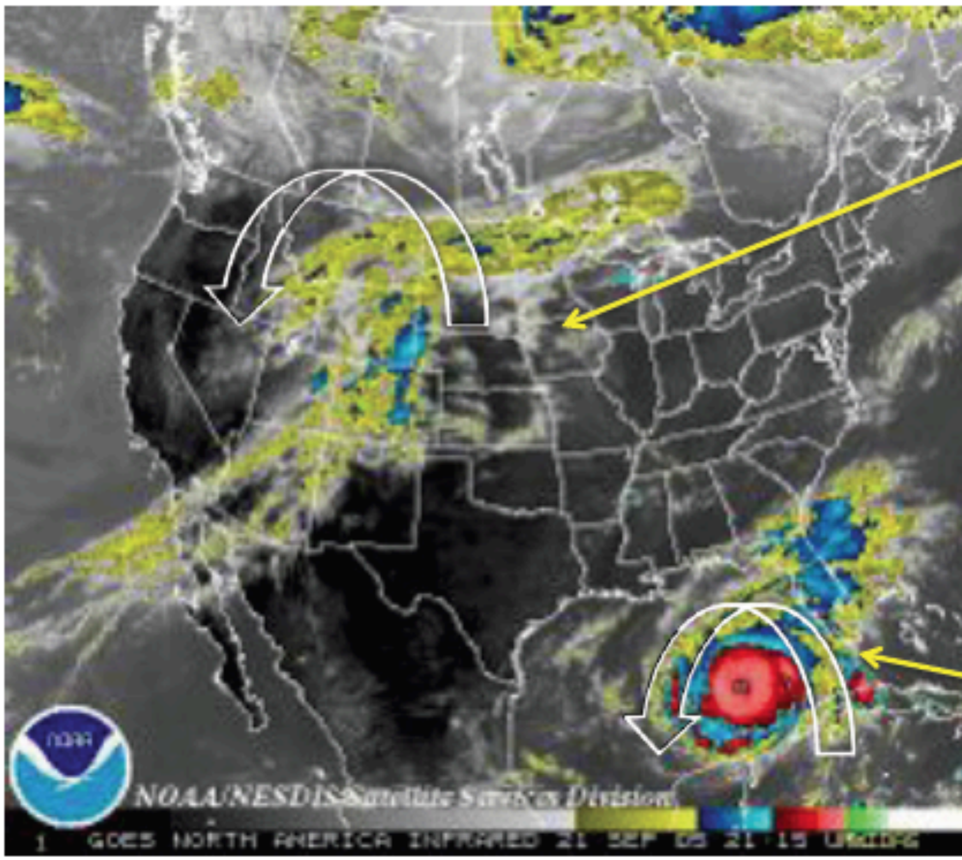
Saffir-Simpson Category	Maximum sustained wind speed		
	mph	m/s	kts
1	74-95	33-42	64-82
2	96-110	43-49	83-95
3	111-129	50-58	96-112
4	130-156	59-69	113-136
5	≥157	≥70	≥137

ATMOSPHERIC STORMS:

(1) Extratropical Cyclones (e.g., Nor'Easters)

(2) Tropical Cyclones (e.g., Hurricanes)

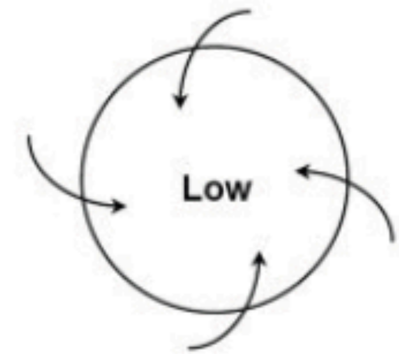
*storms are low pressure systems, hence cyclonic.



Extratropical Cyclone

Tropical Cyclone (Hurricane Rita)

9/21/2005

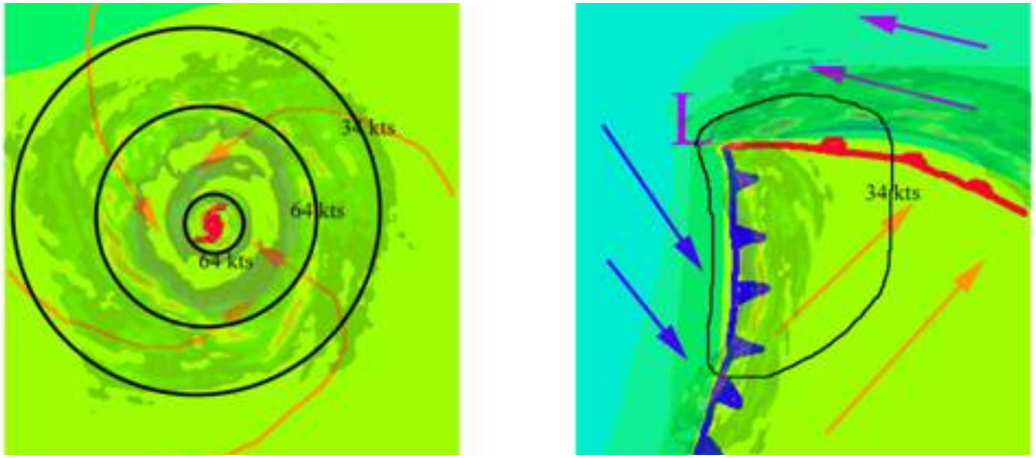


Tropical Cyclones vs. Extratropical Cyclones

Tropical cyclones have more radial shape (circular).

Extratropical cyclone have strong temperature fronts at the surface.

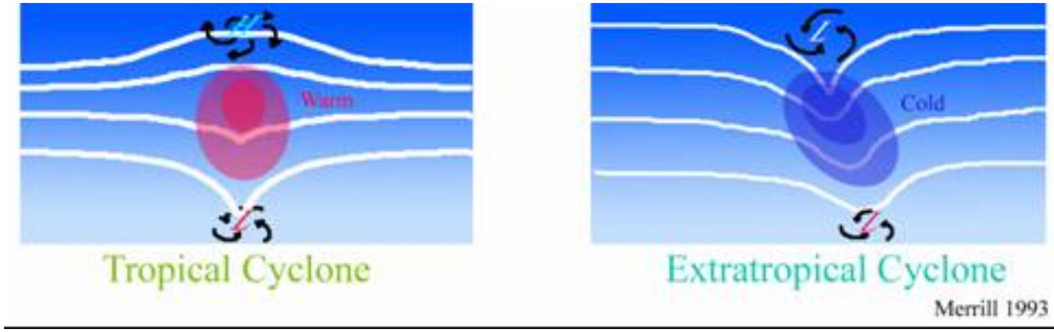
View from above of storm circulation at surface



Temperature differences in the mid-levels of the troposphere

Tropical Cyclones: “warm core”
Extratropical Cyclones: “cold core”

Cross-section
red/blue show temperature anomalies
white contours show isotherms



Example of deep convective cloud

WALLACE AND HOBBS

CHAPTER 8:DEEP CONVECTION

Fig. 8.47 A small isolated cumulonimbus cloud. [Courtesy of Art Rangno.]

Lesson Goals:

- Understand what deep convection is.

- Synthesize the general characteristics of deep convection
- Interpret and be comfortable with CAPE (convective available potential energy)
- Apply the general understanding of deep convection to the dynamics of summertime storms, including those that lead to tornados.

CAPE: Convective Available Potential Energy
THE ENERGY AVAILABLE FOR DEEP CONVECTION

$$CAPE = R_d \int_{EL}^{LFC} (T' - T) d \ln p$$

CAPE can be approximately calculated as the area enclosed by the actual lapse rate and the moist-adiabat for a parcel near the surface .

CIN: Convective Inhibition
THE ENERGY REQUIRED TO LIFT THE PARCEL TO THE LFC

LIFE CYCLE FOR A DEEP CONVECTIVE CLOUD

CUMULUS STAGE MATURE STAGE DISSIPATING STAGE

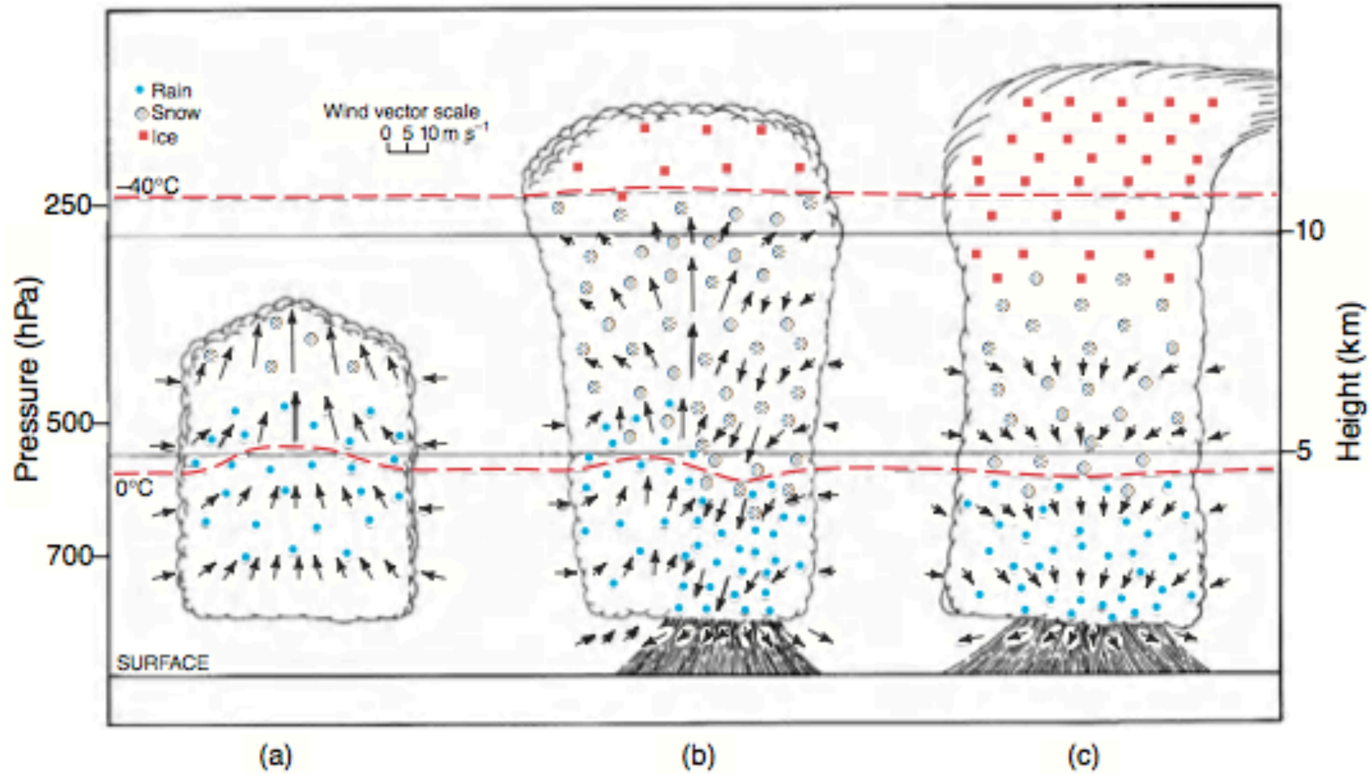


Fig. 8.48 Schematic of a typical ordinary single-cell thunderstorm in three stages of its life cycle showing (a)

CUMULUS STAGE: cloud and rain formation; upward motion dominates

MATURE STAGE: raining; ice formation; upward motion aloft; mixed motion below

DISSIPATING STAGE: rain and ice falling; downward motion through out

WINDS AND CIRCULATION WITHIN A DEEP CONVECTIVE TOWER

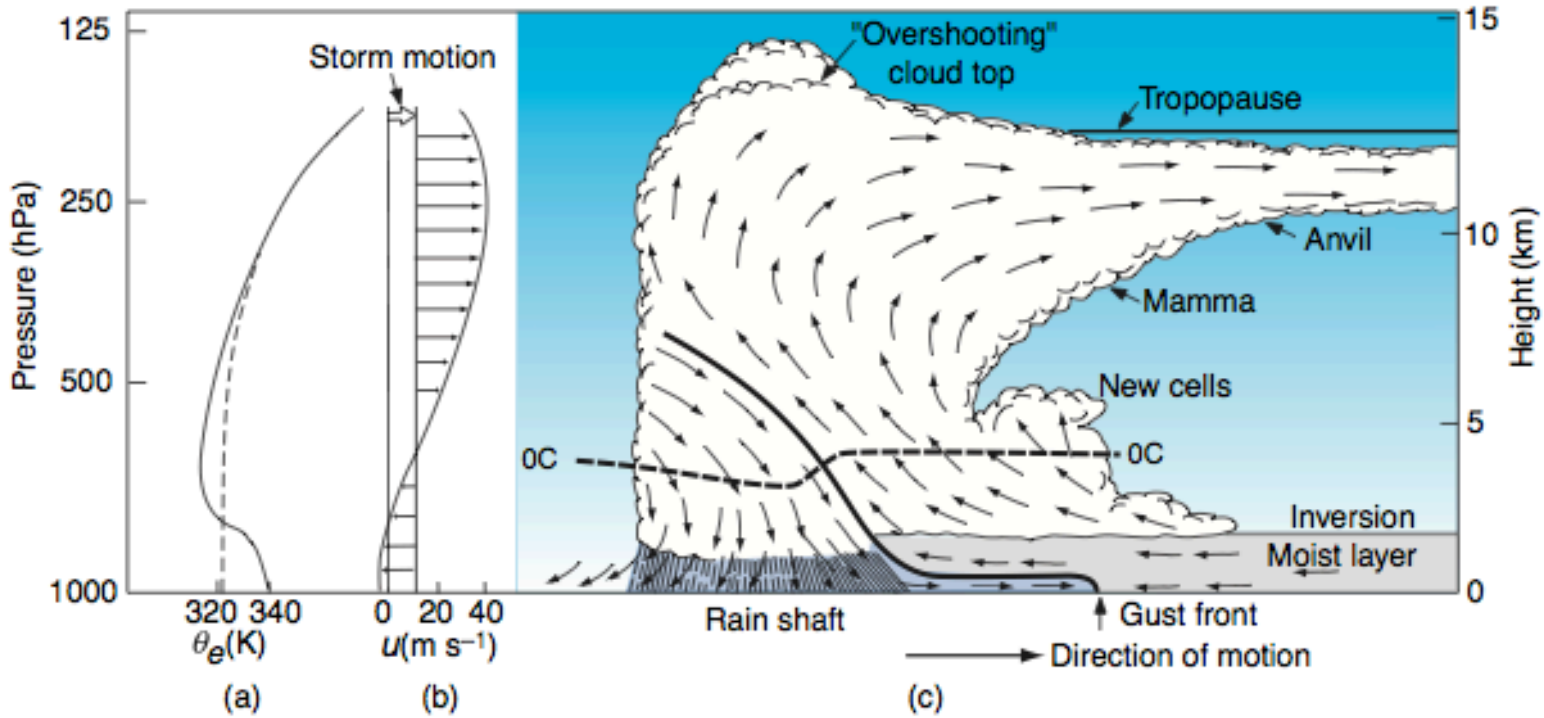


Fig. 8.49 Schematic of an idealized multicell storm developing in an environment with strong vertical shear in the direction of the vertically averaged wind. The vertical profile of equivalent potential temperature θ_e in the environment is shown at the left, together with the wind profile. Arrows in the right panel denote motion relative to the moving storm.

KEYS: (1) The entire storm is moving eastward.
(2) Relative to the storm, winds aloft move eastward, winds at surface move westward; i.e., winds aloft are moving faster than avg speed of the storm.
(3) In the region where rain is falling there is descending motion.
(4) Tropopause acts as a "cap" but it is a loose cap.

SUPERCELL STORM

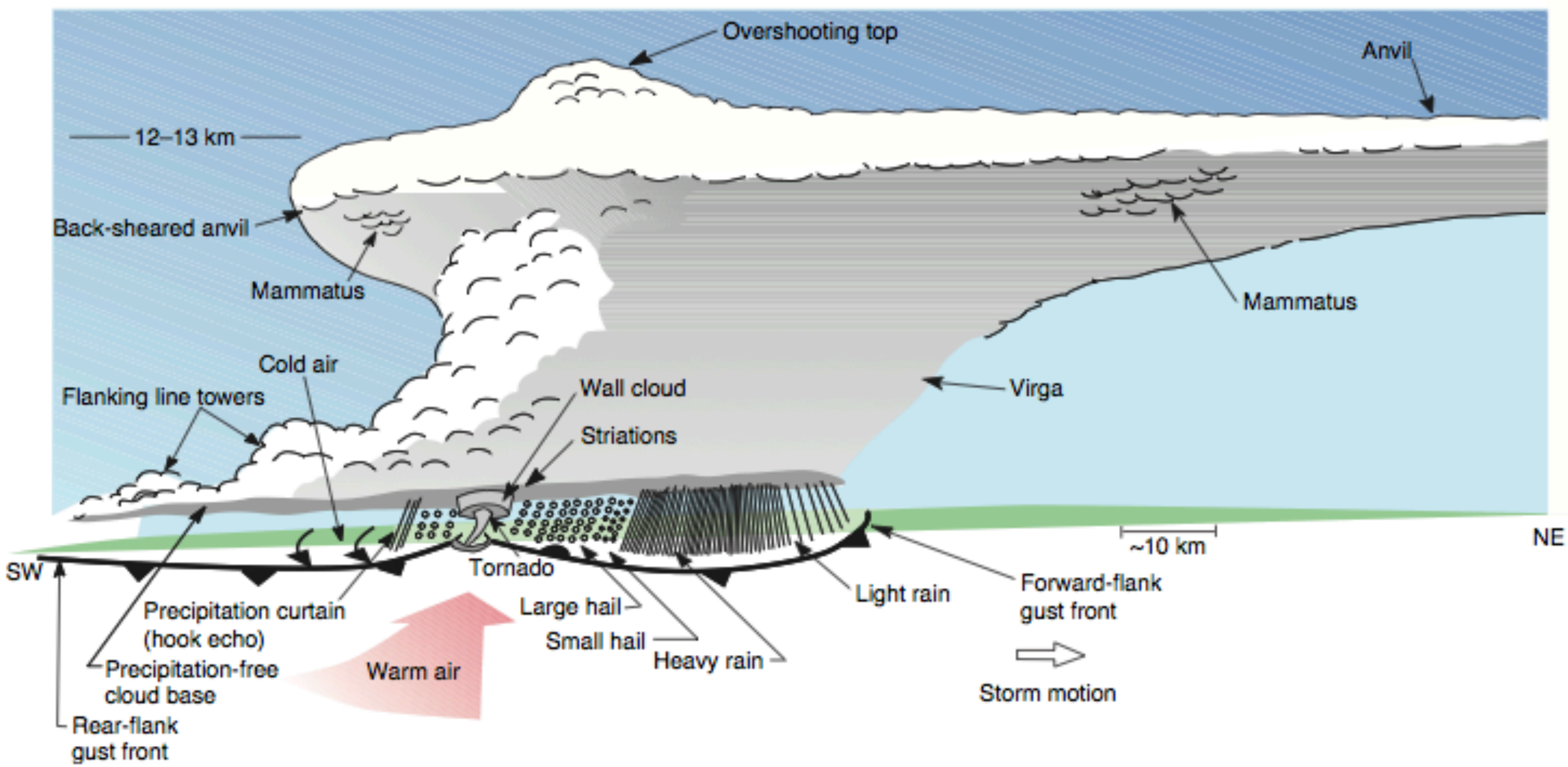


Fig. 8.56 Structure of a typical tornadic supercell storm.[19] Motion of the warm air is relative to the ground. [Based on NOAA National Severe Storms Laboratory publications and an unpublished manuscript by H. B. Bluestein. Reprinted from *Cloud Dynamics*, R. A. Houze, p. 279, Copyright (1993), with permission from Elsevier.]

Keys:

(1) note how small the tornado is relative to the storm cloud.

(2) Tornado forms along a strong temperature front, similar to a CF in an ETC.

(3) Deep convective storm cloud is the major structure in which the tornado forms.

GENESIS OF A TORNADO

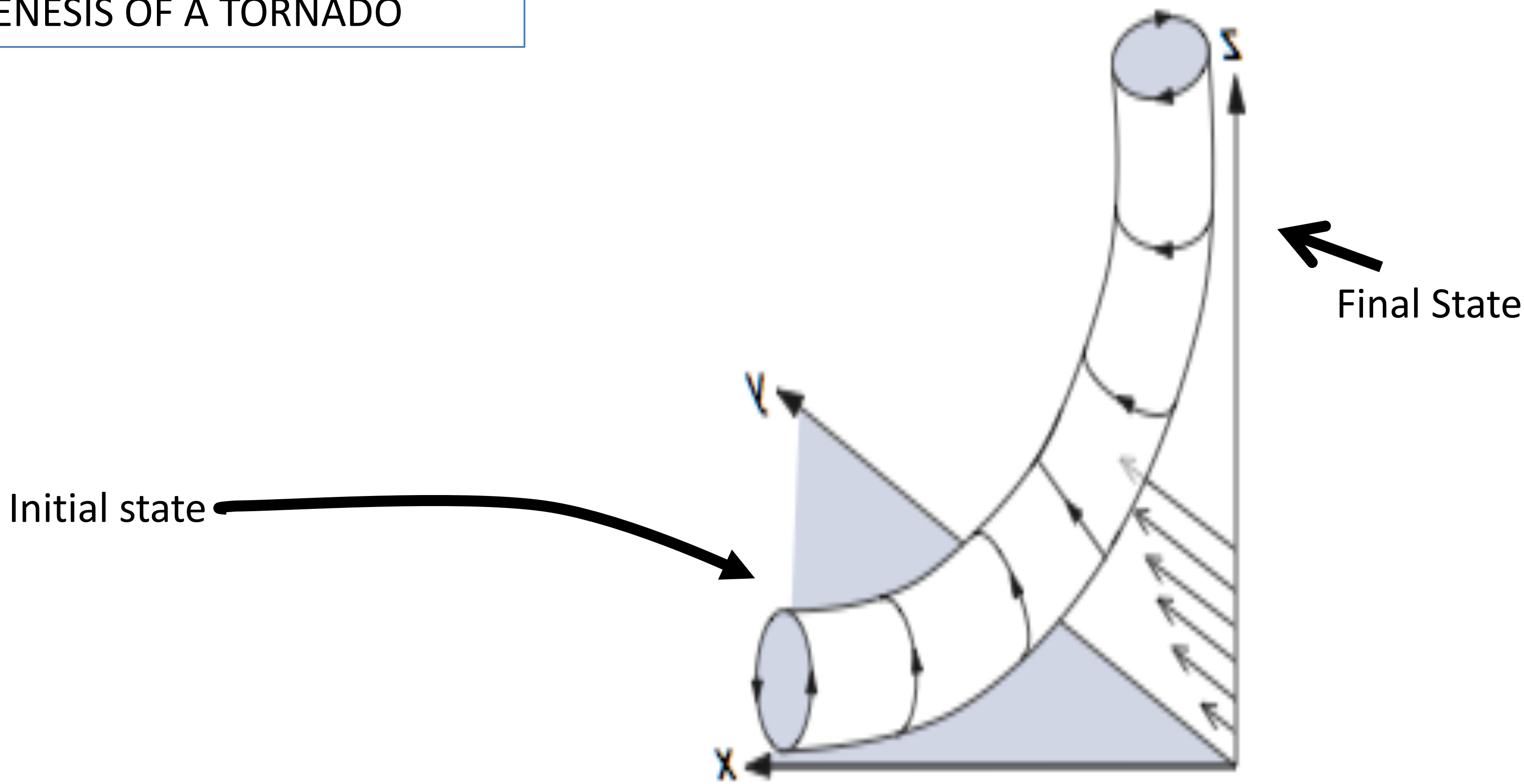


Fig. 8.45 Schematic showing how the updraft of a convective storm can acquire vorticity about a vertical axis by ingesting boundary layer air that possesses vorticity about the x axis by virtue of the vertical shear $\partial u/\partial z$. See text for further explanation.

SEVERE STORM DETAILS

DOWNBURST: Buoyant instability, or forced descent, leading to the mixing down of very strong winds

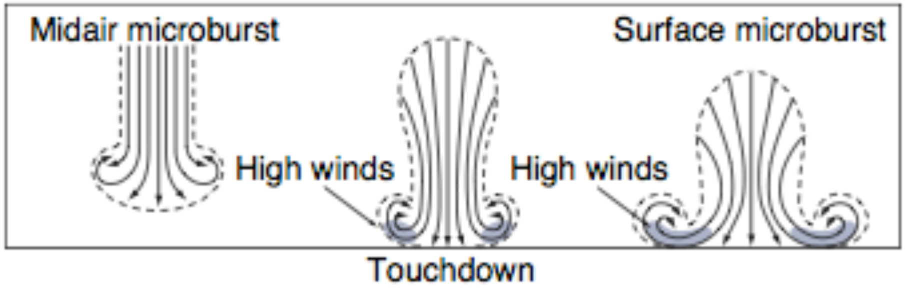


Fig. 8.66 Conceptual model of a downburst. [From T. T. Fujita,[20] *The Downburst–Microburst and Macroburst*. Reports of Projects NIMROD and JAWS, SMRP, University of Chicago, Chicago (1985).]

BOW ECHO: The radar image literally looks like a bow (bow and arrow bow).

Tornadoes and Wind Fronts grow along the edges of the bow.

(Radar show existence of liquid (either rain or cloud) in the air.

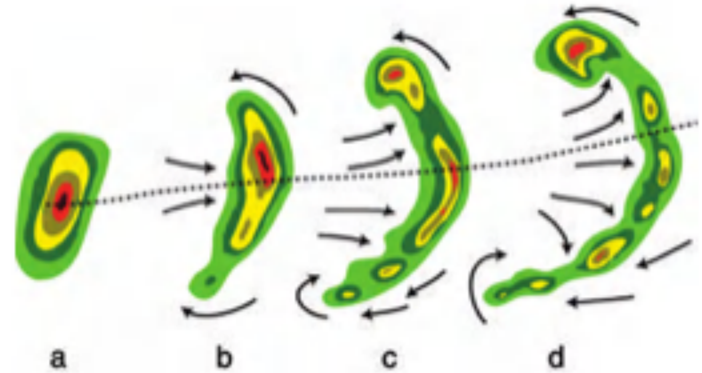


Fig. 8.70 Schematic showing the radar echo of a thunderstorm (a) evolving into a bow echo (b,c) and finally into a comma echo (d) in the northern hemisphere as it moves eastward. Arrows indicate surface winds relative to the moving system. The regions of cyclonic and anticyclonic rotation at the ends of the echo are favored sites for tornado development and the axis of strongest winds is indicated by the dashed line. [Adapted from *J. Atmos. Sci.*, **38** (1981) p. 1528.]