MODULE 3
THUNDERSTORM LIFE CYCLE

OBJECTIVES

At the completion of this module, the student will be able to:

1) Identify the three stages of the thunderstorm life cycle
2) Understand the various characteristics of each stage
3) Visually recognize the cloud structure for each stage

All thunderstorms, regardless of whether they are of the non-severe "airmass" type or the monstrous supercell type, are comprised of **cells** (organized units of convection that are characterized by upward motion in their centers surrounded by sinking motion in the outer regions). Each cell evolves through a three-stage life cycle: towering cumulus, mature and dissipating . How quickly they complete the cycle is dependent upon a number of factors, many of which will be described in later modules.

In this module, we will describe some basic characteristics of each stage of the cycle. Keep in mind that it is virtually impossible to detect the transition from one stage to the next. Further, it is not uncommon for cells within a multi-cellular storm to be in a differing stages of the cycle at any given time.

TOWERING CUMULUS STAGE

Figure 3-1 illustrates the typical cloud structure associated with a cell in the towering cumulus stage of the development cycle. Motion within the cell is primarily upward, with most of the air being drawn up through the cloud from levels below the base. Some ambient air is also drawn into the cloud through its sides, a process known as **entrainment**.

Cloud droplet size is fairly uniform and quite small in the towering cumulus stage. The updraft usually experiences little difficulty in lifting the droplets to higher levels. Vertical motion averages about 20 miles per hour during this stage. There is no precipitation noted in this stage and little, if any, electrical charge separation that would trigger lightning. However, toward the end of this stage, the first identifiable radar echo (radar presentation of an area of precipitation) is noted.

The cloud structure, called a towering cumulus, is also referred to as cumulus congestus. Towering cumulus is indicative of the cloud's growing trend and its accumulation of liquid water. The cells commonly are two to three miles in horizontal diameter.

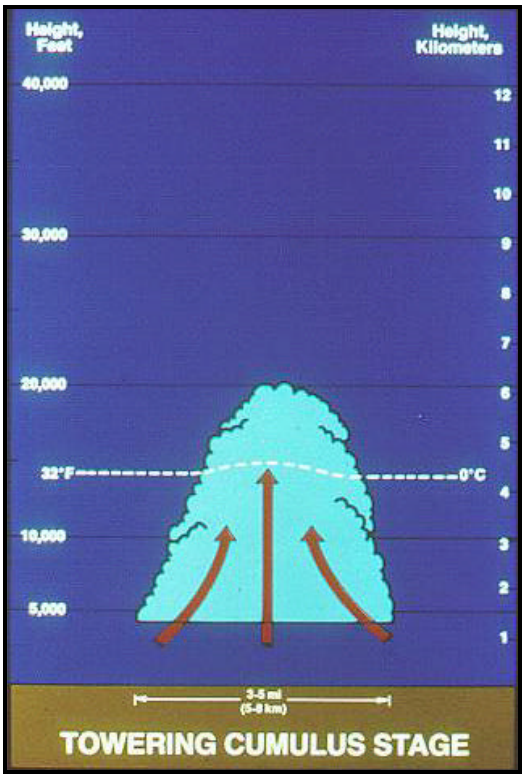

Figure 3-1: The towering cumulus stage of the thunderstorm development process.

MATURE STAGE

Here's where nature lets it "all hang out." Storms that progress in development to severe levels have mature stages that are characterized by very heavy rainfall, vivid lightning, large hail, gusty or possibly damaging straight-line wind, and/or tornadoes. During the mature stage, we typically see the coexistence of an updraft and downdraft. Naturally, the magnitude of these can and do have wide ranges, since some mature stages are more violent than others. On the average, though, vertical velocities are on the order of 30 to 50 miles an hour, but can exceed 100 miles an hour inside a supercell! Upward velocities of this magnitude certainly are capable of supporting very large hailstones.

The cloud grows to heights where the atmospheric temperature is well below freezing (in the -20 to -40 degree Celsius range). Many of the water droplets, now the size of large raindrops, freeze and subsequently grow much faster than do the liquid droplets. Some of the droplets, however, remain in a liquid state at these extremely cold temperatures (these are known as **supercooled** droplets).

The growth of water droplets to a size and weight sufficient to overcome the support of the updraft and fall back toward earth as precipitation is a primary mechanism by which the downdraft forms within the cell. As precipitation starts to fall, friction "drags" some of the air downward with it. In addition, evaporation of rainwater cools the downdraft air and helps accelerate it downward. Other dynamic factors, including pressure differences within the cloud and wind flow interacting with the cloud, make it possible for a very strong downdraft to develop.

This downdraft, which may be associated with very heavy rainfall at the surface, can impact the ground suddenly, rushing outward and causing extensive damage to trees, power lines and structures.

The cloud appearance of a thunderstorm in the mature stage is quite distinguishable (see Figure 3-2). The cloud often is characterized by an extensive cloud shield at the top of the storm that is known as the **anvil.** The anvil is composed primarily of ice particles and spreads out mainly in the direction of the wind at the top of the storm. Anvil formation is a result of the updraft and cloud growth process encountering a strong stable layer aloft that inhibits, or at least retards, further upward motion. This stable layer is referred to as the **equilibrium level**, or EL.

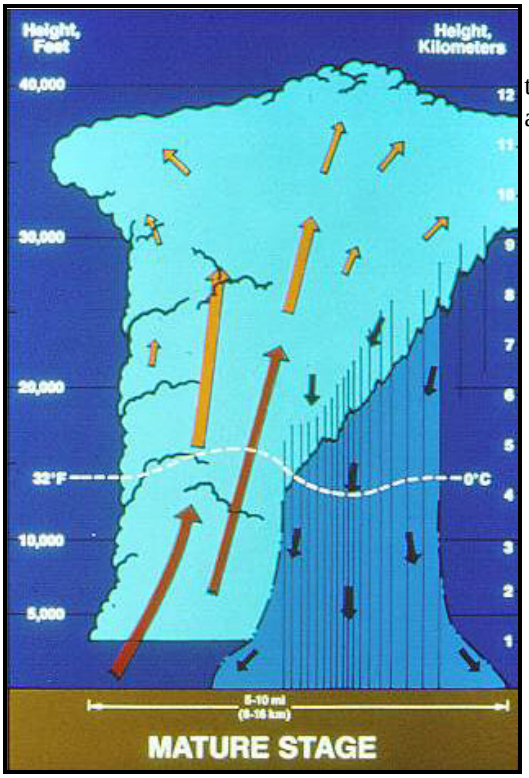

Figure 3-2. The mature stage of the thunderstorm life cycle. The anvil is evident at the top of the storm, and updraft and downdraft areas are marked.

DISSIPATING STAGE

Eventually, the thunderstorm cell will expend its reservoir of energy. As it enters the dissipating stage, the cloud consists mostly of downdrafts and precipitation (see Figure 3-3). Little, if any, inflow is observed that would sustain the cell's life. Thus, the storm essentially "rains itself out".

The dissipating stage may be difficult to identify at its inception. However, as the storm moves further towards dissipation, the cloud base erodes leaving only the middle and top of the cloud visible. The remnant anvil cloud is often referred to as an **orphan anvil**, in that it no longer appears to have an association to cloud elements in the lower levels of the atmosphere.

It is important to note that no two thunderstorms are alike, and as such, characteristics discussed above represent only average depictions of the various stages of development. Many thunderstorms, especially in the warmer climates, may pass through the mature stage without displaying any signs of glaciation that is typical of the anvil cloud. The primary purpose of examining thunderstorm life cycle model is to assist us in organizing our thinking and understanding of how thunderstorms form, persist, and die.

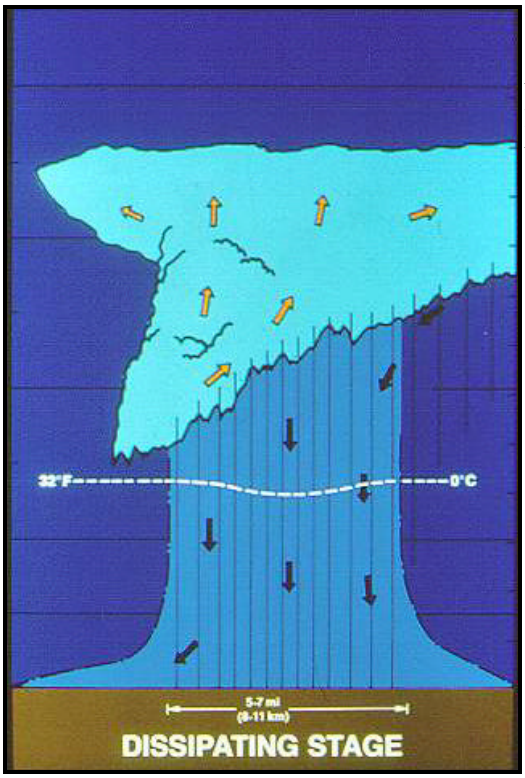

Figure 3-3. The dissipating stage of the thunderstorm's life cycle. Note that the cloud tower has eroded, leaving an "orphan anvil". Precipitation and downdraft are dominant at this time.