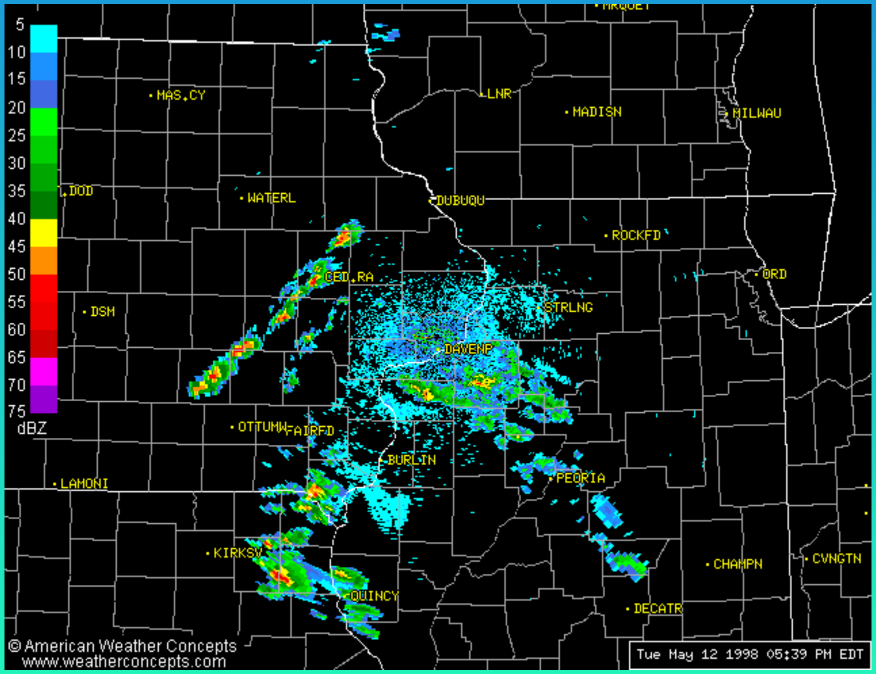
Advanced Spotter Training 2009

Lesson 5: Severe Precipitation



From Last Time

- We learned more about Skew-T diagrams.
- We learned the life-cycle of a thunderstorm.
- We learned of the different kinds of thunderstorms and their severe potential.
- We learned that things in nature are never as simple as they appear in these classes.

This Lesson:

- The process of formation of precipitation.
- The severe-weather potential of precipitation.

Homework Review

Go over the homework problems from last time:

- Develop a series of diagrams to explain the life-cycle of an average thunderstorm.
- Analyze a current Skew-T and locate the cap, if it exists.
- Speculate on why the dissipating stage is often accompanied by strong winds.

Homework Review *(continued)*

- Explain why isolated storms have only a low-probability for developing severe weather.
- Expain why supercells are so dangerous.
- Speculate on the shape of a supercell that splits into a right (cyclonic) and left (anticylonic) part.
- Develop a diagram of a supercell and point out the visible features that make it different from an isolated storm.

Homework Review *(continued)*

- Make a diagram of a thunderstorm cluster and speculate on its capability to produce severe weather. Where will such severe activity be likely to occur?
- Why are squall lines so dangerous?
- Explain the structure of a squall line.
- Speculate on the severe weather potential of an MCC.

Precipitation Formation

- Water exists in essentially three *states* of existence (this is grossly oversimplified, water is a very weird substance).
- The three phases for water are *liquid* (which we are all familiar with), *solid* (ice), and *gaseous* (water vapor).
- These states are called *phases*.
- At the moment we are concerned with water vapor and how it mixes with the air.

Precipitation Formation *(continued)*

- There is a maximum amount of water vapor that the air can hold.
- The percentage of water vapor of this maximum amount is called called the *relative humidity*.
- When the relative humidity reaches 100% then the air cannot mix with any more water vapor.
- This is called *saturation*.

Precipitation Formation *(continued)*

- The amount of water vapor the air can hold changes over time depending on the air temperature and pressure.
- The temperature where saturation occurs without a change in pressure is called the *Dew Point*.
- Saturation can occur any time that the air temperature reaches the dew point.

Precipitation Formation *(continued)*

- If the pressure drops this can cause the dew point to appear to rise suddenly, possibly causing saturation. This is one reason why wall clouds form beneath a vigorous updraft. The updraft represents an area of lower pressure, thus lowering the level where saturation occurs and creating a cloud below the rest of the cloud base.

Precipitation Formation *(continued)*

- Saturation can also occur if the air temperature drops without a corresponding drop in dew point. This is the reason why wall clouds sometimes form tails. Rain-cooled air enters the updraft region and lowers the air temperature leading into the front portion of the wall cloud while actually raising the dew point.

Precipitation Formation *(continued)*

- The ratio of the quantity of water vapor versus the quantity of dry air is called the *mixing ratio*.
- When saturation occurs this ratio is called the *saturation mixing ratio*.
- When the mixing ratio quantity reaches the saturation mixing ratio, saturation will occur.

Precipitation Formation *(continued)*

- Note that there are some conditions where the atmosphere can have slightly more than 100% relative humidity (this is called *supersaturation*).
- Let us assume that we have achieved saturation, does that mean that clouds start forming?

Precipitation Formation *(continued)*

- It turns out that droplets will form easily so long as there are tiny particles of dust or other impurities in the air (this process is called *cloud condensation nucleation* or just *nucleation*).
- These impurities are called *condensation nuclei*, or just *nuclei*.

Precipitation Formation *(continued)*

- The problem is that water evaporates more quickly from a spherical surface than from a flat sheet, so water droplets that are very small evaporate too quickly for clouds to form.
- An effect that can offset this is that droplets formed from solutions evaporate more slowly than for pure water.

Precipitation Formation *(continued)*

- At a certain critical value (based on the size of the condensation nuclei and the level of saturation) the nuclei can form droplets without being stopped by evaporation (this process is called *activation*).

Precipitation Formation *(continued)*

- As more and more droplets form two things happen: the energy holding the water in its gaseous form is released as heat, and the atmosphere can become unsaturated (since water vapor is being taken out of the air) and droplet formation will stop.

Precipitation Formation *(continued)*

- Clouds will continue to form only so long as the atmosphere is saturated.
- One way this continuing saturation can occur is to have a parcel of air reach to the Level of Free Convection where it will have sufficient moisture to continue the cloud-making process.

Precipitation Formation *(continued)*

- As more droplets coalesce larger droplets will form.
- Eventually these droplets will become too heavy to be held aloft, or they will be blown out of the updraft column, and precipitation will form as rain.

First Discussion!

- Speculate on what bands or ribbons of cloud (so-called beaver-tails) being drawn into a thunderstorm indicates.

Section 2

Hail

Hail Formation

- At higher altitudes it is possible for certain types of nuclei (called *ice nuclei*) to cause water droplets to freeze in any of a few ways to cause ice crystals to form.
- As these ice crystals move around they may come into contact with pure water droplets at low temperatures (called *supercooled*, they are still liquid since they do not have an ice nucleus).
- When this happens the supercooled droplet instantly freezes onto the crystal.

Hail Formation *(continued)*

- This process is called *accretion* or *riming*.
- In this way large balls of ice can form as layer after layer of riming occurs.
- Eventually the ice ball gets too heavy for the updraft and it falls, or is blown downstream by upper-level winds.
- This is how hail forms.
- This process requires cold temperatures aloft and a balance of water vapor and a source of ice nuclei.

Hail Potential from Isolated Storms

- The isolated thunderstorm can produce small hail if atmospheric conditions are favorable.
- However these storms will produce hail at or near severe limits for only a couple of minutes.
- Such events signal the onset of short and sporadic bursts of severe activity.
- This is what we call *pulsing severe storms*.

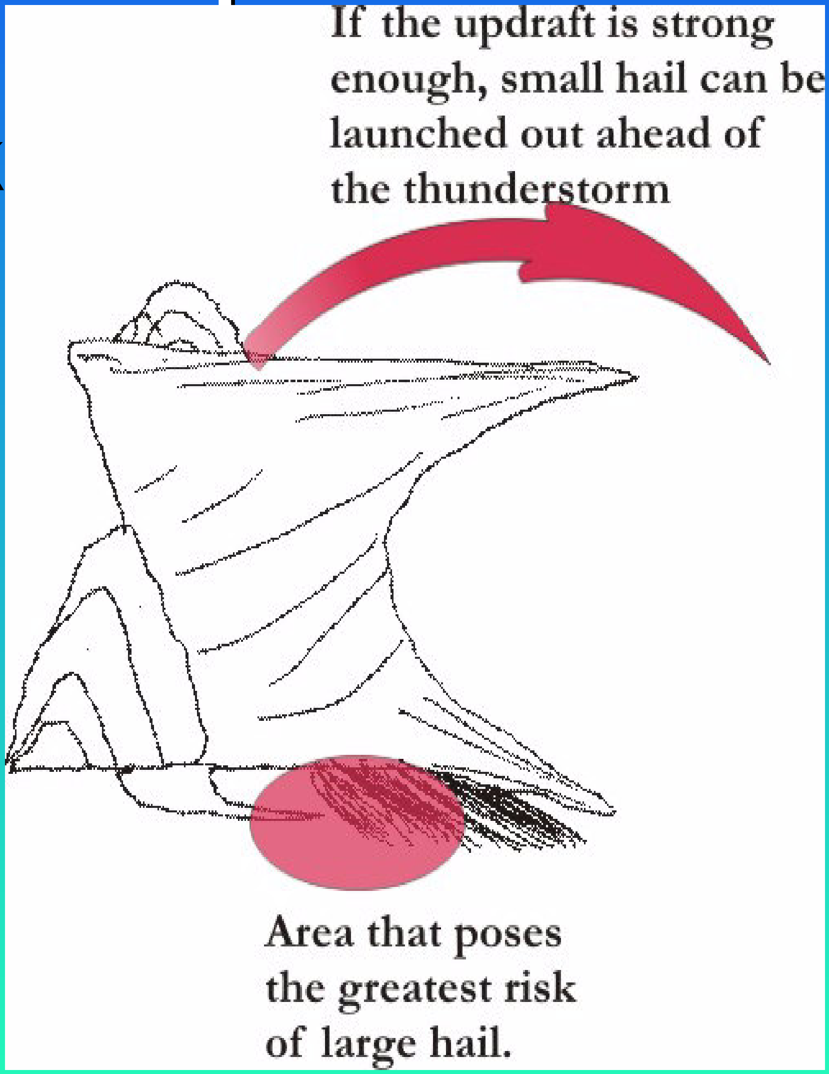
Hail Potential from Supercell Thunderstorms

Supercells have a much greater potential for damaging hail. This is for two reasons:

- They are physically taller and have access to the colder levels of the atmosphere.
- They are longer lived and thus have a better chance of acquiring ice nuclei in sufficient quantities to cause hail to form.

Hail Potential from Supercell Thunderstorms *(continued)*

- Look at your diagram of the supercell thunderstorm you made as part of your homework from lesson two.



Hail Potential from Supercell Thunderstorms *(continued)*

- Very large hail can form on the back side of the forward flank downdraft, and can even be carried around the mesocyclone by the rear-flank downdraft.
- You can be watching a tornado in the inflow region under the updraft and have high winds and hail hit you from your left as the RFD punches into you.

Hail Potential from Thunderstorm Systems

- A multicell cluster produces hail in a manner similar to isolated thunderstorms, except that the risk is somewhat higher since you have so many cells moving through an area.
- Such storm trains need to be watched for pulsing severe weather.
- Multicell clusters are longer lived and thus have a better chance of acquiring ice nuclei in sufficient quantities to cause hail to form.

Hail Potential from Thunderstorm Systems *(continued)*

- The squall line seems to be a frequent hail producer.
- This makes sense since cold air is being driven lower into the atmosphere by the downdraft of the storms.
- Widespread large hail can occur with such systems.
- MCCs are capable of producing hail when the temperatures cool sufficiently, and there are enough ice nuclei.

Hail Potential from Thunderstorm Systems *(continued)*

- Such hail will tend to be small, but could be quite widespread

Second Discussion!

- Think about the danger that hail poses to spotters

Section 3

Flash Flooding

Flash Flooding

- When too much rain falls over an area for existing waterways to carry the water away flash-flooding can occur.
- Flash flooding is very dangerous.
- Imagine someone hitting you with a gallon of milk moving at 30 miles-per-hour or more!
- Now imagine a torrent moving thousands of gallons into you every second...
- That's a flash flood.

Flash Flooding *(continued)*

- Four inches of fast moving water is capable of floating your car away, six will take out your truck, either can destroy your house and sweep you away.

Flash Flooding Potential from Isolated Storms

- The flash flood potential for isolated thunderstorms is very limited.
- Only if the thunderstorm is very slow moving does it have much of a chance of producing such flooding.

Flash Flooding Potential from Supercell Thunderstorms

- The flood potential of a supercell is higher, especially with HP-type storms.
- Since the supercell has access to greater quantities of moisture there is more potential for rain.
- If a supercell is slow-moving chances are that it will produce flash flooding, unless it is an LP storm.

Flash Flooding Potential from Thunderstorm Systems

- Storm trains have a good chance of producing flash flooding since there will be numerous cells passing over the same area.
- Squall lines can deposit enormous quantities of rain over a wide area, but unless they are slow-moving there is not a high risk of flash flooding.

Flash Flooding Potential from Thunderstorm Systems *(continued)*

- If the bow starts moving well ahead of a flank, that flank can be pulled in the direction the line is moving and become a storm train.
- MCCs can produce large quantities of rain and must be monitored for the possibility of flash flooding, particularly in areas that have gotten heavy rain recently.

Final Discussion!

- Think about the danger that flash flooding poses to spotters

Homework Due Next Week

- Explain the process of precipitation formation.
- Speculate on how this knowledge can help you as a spotter.
- Explain how hail forms.
- Draw a diagram of each type of storm and include where to look for hail.

Homework Due Next Week *(continued)*

- Get a tape measure (if you do not already have one), for measuring water depth when making a report. If you are a static spotter, get a rain gauge and learn to read it.
- Think about what not to do in flash floods.