Advanced Spotter Training 2009

Lesson 6: Severe Winds

From Last Time

- We learned how clouds and precipitation form.
- We learned how hail forms.
- We learned about flash flooding.
- We learned the severe precipitation potential of various types of thunderstorms.

This Time

- In this lesson we will discuss severe wind events.
- We will begin by covering how thunderstorms produce wind, then we will cover the dangers of wind, and finally we will cover the types of wind events that can occur in the vicinity of severe thunderstorms.

Homework from Last Time

- 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 from Last Time (*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.

Wind

- Simply put, wind is moving air.
- When a gas is confined to a volume and is lighter than the gas surrounding, it will begin to rise.
- This rising is called *bouyancy*.
- The continuation of the updraft, of a thunderstorm, is driven by the buoyancy of the warm air after it has shed its water vapor due to condensation.

Wind *(continued)*

- So long as this buoyancy is positive (in the upward direction) the air will rise.
- We have already seen how this occurs in lessons 3 and 4.

Wind *(continued)*

- As the air rises, the low pressure created by the updraft draws more air into the thunderstorm at the surface.
- This provides more air for the updraft of the thunderstorm.
- This is one source of the inflow winds at the surface.
- The storm is, in effect, sucking in air from the surrounding environment.

Wind *(continued)*

- Rain forms as described in the last lesson.
- The force that is generated when air pushes on an object is called *drag*.
- Drag is also generated when an object moves through the air.
- As the rain falls it introduces a drag effect on the surrounding air.

Wind *(continued)*

- This drag effect will have a tendency to pull air down with the falling rain.
- This is one way that thunderstorm downdrafts can be generated.
- It is not the major contributor to thunderstorm winds though.
- As precipitation falls into warmer air, it can get warm enough to mix with the surrounding air.

Wind *(continued)*

- If the saturation point is not reached, evaporation will occur.
- This evaporation will have the effect of cooling the air (called *evaporative cooling*).
- When a gas is denser/cooler than its surroundings, it sinks.
- This sinking is called *negative bouyancy*.

Wind *(continued)*

- The rain-cooled air in a downdraft column will exhibit negative buoyancy.
- This means that a parcel of air can no longer overcome the pull of gravity.
- Every object that falls through a gas falls with a maximum velocity, called *terminal velocity*.

Wind *(continued)*

- Since this cooled air is falling, it will accelerate up to its terminal velocity (which depends on how large the parcel of air is).
- This process of evaporative cooled-negatively bouyant air is the primary source of severe winds.
- When such a parcel hits the ground it will spread out in all directions.

Wind *(continued)*

- If the thunderstorm is moving forward, the winds in that direction will be stronger since the forward motion of the storm is added to the wind.
- Likewise, the winds behind where the parcel makes impact will be lessened by the forward motion of the storm.
- This is called a downburst, and winds have exceeded 150 miles per hour in particularly strong downbursts.

First Discussion!

- Think about what factors might contribute to making the winds stronger.

Section 2

The Severe Potential of Wind

Loading and Structural Failure Due to Wind

- When the wind hits an object it pushes against it.
- This generates a force that is called *loading*.
- There are two factors that determine how something will respond to the wind; the first is the speed of the wind, and the second is the surface area of the object.
- The higher the wind speed, the more wind that will hit an object; this is similar to the discussion for a flash flood.

Loading and Structural Failure Due to Wind *(continued)*

- So long as the wind speed remains at a certain point, you will experience a flow of air into and around an object at a constant rate.
- If this number is high, a lot of air is going to hit the object we are considering.

Loading and Structural Failure Due to Wind *(continued)*

- A sheet of plywood two feet on a side experiences four times the force of a one foot square, a three foot square experiences nine times the force, and so on; the force goes up as the square of the area of the surface.
- A high wind striking a large surface, like the side of a building, can generate huge forces.

Loading and Structural Failure Due to Wind *(continued)*

- After a certain point the structure can no longer hold up under the load.
- The structure will buckle.

The Danger of Flying Debris

- Since wind exerts a force on objects it strikes, there is a possibility (especially in high winds) for small objects to be swept away in the wind.
- Most injuries from severe weather come from wind-blown debris.
- It is also possible for wind-blown debris to penetrate a structure.
- Say you have a strong wind that is pushing against a structure; then some debris comes through a window.

The Danger of Flying Debris *(continued)*

- This breach allows wind into the structure.
- If the wind is strong enough, this can be like blowing up a balloon, and the structure will actually expand.
- If this goes beyond a certain point the structure will separate and fly apart.

The Danger of Flying Dust and Wind-Driven Rain

- Another danger from wind is a rapid decrease in visibility due to driven rain and dust.
- Particularly for mobile spotters this can be life-threatening as a traffic accident can easily result in such conditions.
- This is also true for spotters who have stopped by the side of the road to observe a storm.

Second Discussion!

- Think about some specific dangers of wind.

Section 3

Severe Wind Events

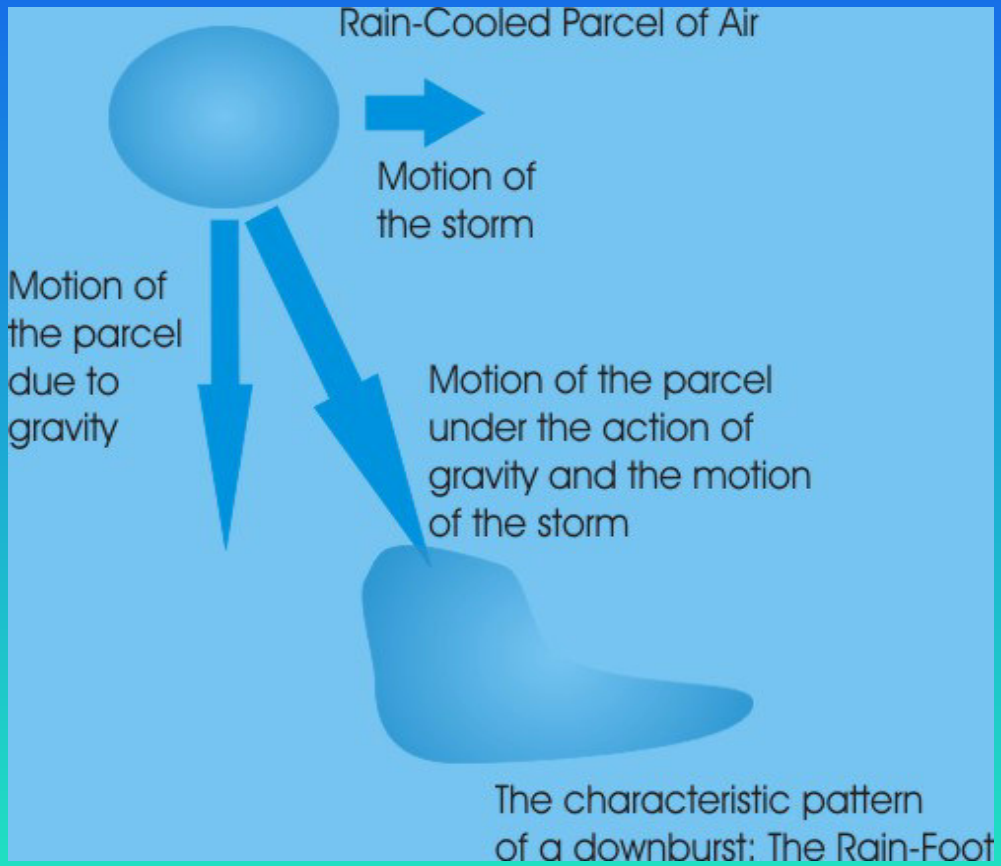
The Gust Front

- If you think about the downdraft of a thunderstorm you will realize that it pushes air out ahead of the storm.
- This is sort of like a bubble of air on the ground that spreads out in every direction.
- Since the storm is moving in a specific direction, this outflow will tend to be stronger in the dirtection of motion of the storm.
- This area of wind that precedes the storm is called the *gust front*.

The Gust Front *(continued)*

- Winds in the gust front will be faster than the forward motion of the storm.
- If the storm is fast moving, these winds can easily be severe.

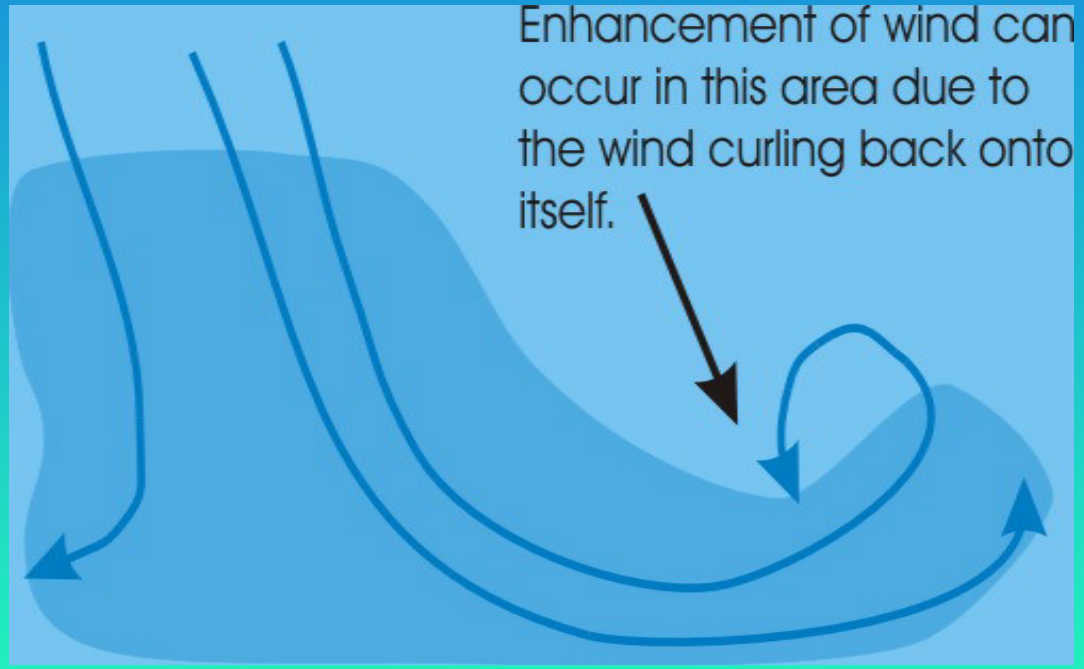
The Downburst



- Occasionally a parcel of air is so rapidly cooled that it acquires a very strong negative buoyancy.

The Downburst *(continued)*

- This will be most susceptible to the acceleration due to gravity. It will thus fall very quickly and hit the ground very hard.
- The result is a *downburst*, as seen in the diagram above.
- If we look at the wind patterns in the downburst we see some interesting features.



The Downburst *(continued)*

- You will occasionally see cloud formation on the leading edge of the rain foot.
- It will appear that cloud fragments are being draw upward and this is a source of false tornado reports.

The Downburst *(continued)*

- You may also see the development of cloud matter in a line within the area where wind is curling back on itself allowing the cloud to rotate about a horizontal axis, this is called a *roll cloud*.
- A downburst that is on the order of 2 kilometers or less in its frontal extent is called a *microburst* and can have devastating effects on aircraft attempting to land at airports.

The Downburst *(continued)*

- Downbursts produce most of the outflow of a thunderstorm.
- It is possible to get clear air microbursts if rain is evaporating before it hits the ground.
- Such an effect is called *virga* and can happen in LP storms.
- Such downbursts are called *dry microbursts*.

The Downburst *(continued)*

- A microburst in a precipitation column is called a *wet microburst*.

The Derecho

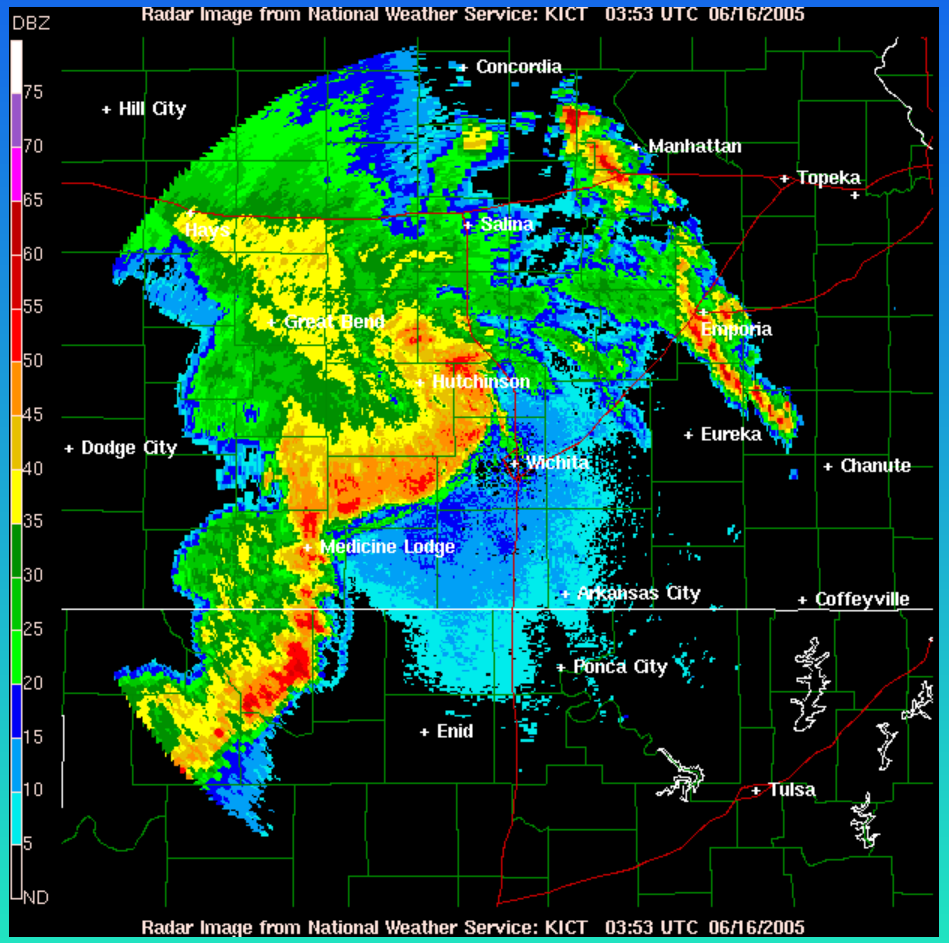
- Occasionally a downburst will carry jet stream winds to ground level.
- This can be mid-level jet streams in the case of supercells and LEWPs, or high-level jet streams in the case of squall lines.
- As discussed previously, supercells can (and often do) evolve into squall lines.
- In such cases, winds of over one hundred miles per hour are not uncommon.

The Derecho *(continued)*

- As you can imagine these storms can bring widespread damage.
- Derecho's can last for hours, so long as they continue to have their source of jet stream winds.

Final Discussion!

- Discuss the evolution of derechos.



Homework Due Next Week

- Describe how a downdraft produces wind at the surface.
- Describe the effect of evaporative cooling.
- Explain how structures fail under the action of wind.
- Speculate on the risks of flying debris posed to spotters in the field. How would you avoid such risks?
- Speculate on the severe potential from a gust front.

Homework Due Next Week *(continued)*

- Speculate on the severe potential from dry microbursts.
- Explain how a derecho happens.