ESCI 241 – Meteorology
Lesson 17 – Thunderstorms and Tornadoes
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THUNDERSTORMS

- **A *thunderstorm* is a storm that produces thunder and lightning.**
- **Normally the vertical motion in the atmosphere is very slow, on the order of centimeters per second (about one-tenth of a mile per hour).**
- **In a thunderstorm, updrafts can easily exceed 50 mph, and have been observed at over 80 mph.**
- **Thunderstorms require some lifting mechanism to start the initial upward motion. This mechanism can be any one of the four lifting mechanisms that we discussed earlier in the semester**
  - **Orographic lifting**
  - **Frontal wedging**
  - **Convergence**
  - **Convective lifting**

DISTRIBUTION OF THUNDERSTORMS

- **On average there are about 45,000 thunderstorms around the world every day.**
- **Most thunderstorms occur over land, and in the Tropics.**
- **Each year the U.S. experiences around 100,000 thunderstorms.**
- **Florida and the Gulf Coast experience the most thunderstorms in the U.S., because mT air that moves over the hot land is very unstable.**
- **Eastern New Mexico and Colorado also experience numerous thunderstorms, due to mT air moving upslope toward the Continental Divide.**
- **The fewest thunderstorms occur on the West Coast, because mP air is very stable.**

AIR MASS THUNDERSTORMS

- **Air mass thunderstorms are associated with mT air.**
- **Stages of development of air mass thunderstorms**

- **Cumulus stage – strong updrafts build the storm**
- **Mature stage – precipitation begins. Downdrafts form from both the frictional drag of the precipitation, and due to entrainment of dryer air and evaporation of precipitation.**
- **Dissipating stage – downdrafts have shut off the updrafts that feed the storm. Clouds evaporate as the storm dissipates.**

- **Air mass thunderstorms are more likely to occur over mountains or hills, due to differential heating and orographic lifting.**
- **The sea-breeze is a common cause of air-mass thunderstorms along Florida's coast.**

GUST FRONTS AND DOWNBURSTS

- **Thunderstorm downdrafts are cool because of two factors:**
  - ***Entrainment* of unsaturated, cooler air from outside of the thunderstorm.**
  - **Evaporation of precipitation into the air**
- **As the cool downdraft hits the ground it spreads out.**
- **The leading edge of the downdraft acts like a miniature cold front, and is called the *gust front*. As the gust front passes the wind become gusty, and the temperature drops.**
- **The lifting of warm, moist air along the gust front can trigger new thunderstorm development.**
- **If the downdraft is very strong it is called a *downburst*. Downbursts can be quite damaging to trees, building, power lines, and airplanes. They are often mistaken for tornadoes by people who experience them.**
- **A very narrow downburst is sometimes called a *microburst*.**

SEVERE THUNDERSTORMS

- **A thunderstorm is classified as *severe* if any one of the following conditions are met:**
  - **It produces winds in excess of 50 knots (58 mph).**
  - **It produces hail larger than one inch in diameter.[1]**
  - **It produces a tornado**
- **Severe thunderstorms are often produced beneath the jet stream or other region of strong upper level winds.**

OTHER CLASSIFICATIONS OF THUNDERSTORMS

- **Thunderstorms are also classified according to the number and strength of the updrafts, or *cells*.**
  - **In a *single-cell* thunderstorm there is only one main updraft and downdraft. Most air mass thunderstorms are of this variety.**
  - **If there is more than one updraft present than we have a *multi-cell* thunderstorm.**
  - **If there is a single, large updraft that is rotating then we have a *super-cell* thunderstorm.**
- **The vertical profile of the winds determines whether the storm will be single-, multi-, or super-cell.**

SQUALL LINES

- **Squall lines are narrow, fast moving lines of thunderstorms that occur a hundred or so miles ahead of a cold front.**
- **Squall lines sometimes form along the *dryline*, a boundary between cT and mT air over West Texas, Oklahoma, and Kansas.**

MESOSCALE CONVECTIVE COMPLEX (MCC)

[1] Prior to January 5, 2010 the cutoff size was ¾ inch diameter.

- **Mesoscale Convective Complexes are very large groups of thunderstorms that form in the late afternoon or evening over the Great Plains, and persist for up to 12 hours or more.**
- **MCC's are responsible for a large amount of the rainfall received in the Central U.S.**

TORNADOES

- **Tornadoes are rotating columns of wind that form beneath some severe thunderstorms.**
- **Tornadoes form and sustain themselves due to *vortex stretching*.**
  - **Vortex stretching refers to what occurs when a column of air that is initially rotating only slowly is stretched along the axis of rotation. As the column of air stretches it also becomes skinnier. Because of conservation of angular momentum, as the column becomes skinnier it begins to spin faster.**
  - **Vortex stretching occurs in your bathtub or sink, and is why a whirlpool often forms in a draining bathtub.**
- **This vortex stretching can occur in a thunderstorm updraft, and can cause the vortex to rotate at incredible speeds (over 250 mph!).**
- **Small tornadoes can form due to the vertical wind shear near the ground.**
- **Initially, the rotation will be along a horizontal axis, but the thunderstorm updraft can tilt the rotation to the vertical, and then stretch it.**
- **Tornadoes formed in this manner can spin either clockwise or counterclockwise.**
- **The larger, and most devastating tornadoes form from super-cell thunderstorms.**
- **The updrafts in super-cell thunderstorms already are slowly spinning in a counterclockwise (cyclonic) direction. This is often referred to as a *mesocyclone*.**
- **The tornado, and vortex stretching, occur within the mesocyclone.**
- **Tornadoes formed in this manner always rotate counterclockwise.**
- **About 80% of tornadoes spin counterclockwise.**
  - **This is not directly due to the Coriolis force acting on the tornado, because tornadoes are too small to directly feel the effects of the earth's rotation.**

Instead, it is because the storms that spawn the tornadoes (the mesocylones) are large enough to feel the effects of rotation.

- **A tornado may have multiple suction vortices.**
- **Although the visible part of the tornado usually extends from the cloud and moves toward the ground, the suction in the tornado is actually upwards.**
- **The cloud forms in the vortex because pressures are low enough to cause the air to adiabatically cool to saturation.**
- ***In order to be classified as a tornado, the vortex must reach the ground*. Otherwise, it is just reported as a *funnel cloud*.**
- **A tornado that occurs over water is called a *waterspout*.**

TORNADO CLIMATOLOGY

- **Tornadoes can occur during any month of the year.**
- **Tornadoes have been reported in every state of the U.S.**
- **Most tornadoes, however, occur during the Spring, and over the Great Plains.**
- **this is because the conditions for forming severe thunderstorms (the collision of mT air with cP air) often occur in this region at this time of year.**
- **Since most tornadoes form in the mT air ahead of a cold front, where the prevailing flow is southwesterly, most tornadoes move toward the northeast.**

THE *F-SCALE* OF TORNADO INTENSITY

- **Tornado intensity is measured on a scale created by Dr. Ted Fujita, a noted tornado researcher. It is referred to as the *F-scale*.**
- **Since tornado winds cannot be measured directly, the F-scale is based on the damage caused by the tornado.**
- **The F-scale goes from F0 to F5, with F0 being light damage, and F5 being incredible damage.**

TORNADO SAFETY

- **Pay attention to the TV or radio when thunderstorms are in your area, and listen for the issuance of Tornado Watches or Tornado Warnings.**
- **Keep a battery operated AM or FM radio available.**
- **You may want to purchase a *weather-band* radio.**
- **The National Atmospheric and Oceanic Administration (NOAA), the parent organization of the National Weather Service, operates radio stations that continually broadcast weather information.**
- **Radios that can receive these broadcasts are relatively inexpensive, and can be bought at most electronic stores.**
- **Some of these radios even have alarms on them that will sound if a tornado watch or warning has been issued.**

TORNADO WATCHES AND WARNINGS

- **A *Tornado Watch* means that the conditions are ripe for tornado formation, and that tornadoes are possible.**
- **A *Tornado Warning* means that a tornado has been spotted.**
- **If a *Tornado Warning* has been issued**
  - **Seek shelter immediately!**
  - **Go to the lowest level of your building.**
  - **If possible, get into the basement, or into an interior room (but away from any windows or doors to the outside).**
  - **Look around to make sure there are no heavy or glass objects near or above you.**
  - **If possible, cover yourself with pillow, blankets, or a mattress.**
  - **Keep monitoring the radio or TV for updated information.**