Basic Ingredients for Thunderstorm Activity

1) General Setting

All thunderstorms are similar in that several basic ingredients are required in order for them to develop and thrive.

All thunderstorms must have the following in order to exist:

- Atmospheric instability
- Available moisture
- Rising motion (trigger mechanism)

If any of these three items are missing or available in limited quantities, thunderstorm activity will be sparse, or non-existent.

Let's look briefly at the above three parameters:

Atmospheric instability:
This essentially is a measure of how fast the temperature drops off with height. A more rapid decrease of temperature with height means greater instability. To measure instability, we use data from balloon ascents and compare temperature measurements at different heights. This gives rise to several "stability indices". The ones we use most often for SKYWARN operations are the Lifted Index and SWEAT (Severe Weather Threat).

Available moisture:
This can be measured directly by scrutinizing surface dewpoints, and the dewpoint in the lower 5,000 feet of air. This also is plotted, and then analyzed in two degree intervals. When the above two items are analyzed on a US map, we have a good idea of where the potential hot spots will be for thunderstorm development on a given day. These features many times evolve slowly.

Triggering mechanisms:
This includes anything that causes the air to rise, including frontal systems, the jetstream, mountain ranges. The forecasting problem essentially is one of predicting when and where one (or more) of these triggers will interact with a region already defined as favorable in terms of stability and moisture.

2) Thunderstorm Review
Individual thunderstorms undergo several distinct stages of development during their life cycle. Anyone working close to the field of meteorology is familiar with the "updraft", "mature" and "dissipating" stages of activity. Thunderstorms are constantly evolving with time, and all three of these phases in the "life" of a thunderstorm usually occur in about a 30-40 minute period for a typical thunderstorm.

To understand the short duration of many thunderstorms we must examine the upper wind structure at the time of the thunderstorm. In summer, winds aloft are rather light. Thus, a rising column of air progressing upward toward the 30,000 and 40,000 foot levels can grow almost vertically. This means that immediately after the updraft stage, when the rising column of air reaches its peak altitude, it collapses directly down into itself (signaling the mature stage). With upward momentum now changed to downward momentum, the thunderstorm must weaken and die.

Many thunderstorms develop in an environment where winds increase with height, as in the vicinity of the jetstream. In these cases the rising current of air is no longer a vertical column, but rather a tilted column. This means that as the updraft reaches the 30,000 and 40,000 foot levels, it is tilted downstream as compared to the base of the column at 5,000 feet. When the downdraft develops, it falls downwind of the updraft instead of choking it off. These thunderstorms exist for much longer periods of time and become more intense. This is the reason why thunderstorms located near the jetstream tend to be more intense than those found in a light windflow. This is also the reason why Minnesota and the upper Midwest receives most of its severe weather in April, May and June. These are the months when the jetstream is still strong, and located over our region.

3**) Triggering mechanisms** which many times initiate thunderstorm development in the Minnesota area:
Cold Front: Air at the surface tends to be forced upward by the cold air wedging beneath the milder air ahead of it. The amount of lift depends on the strength of the surface winds, the amount of directional shift, and the temperature difference across the front.

Warm Front: Air at the surface is lifted upward as the warm air rides over the retreating colder surface air. The amount of lift depends on the windspeed in the warmer airmass and how fast the colder airmass is pulling away.

Sun's Heating: Most times, thunderstorms develop in the late afternoon or early evening. A full day of intense heating from the sun often makes the atmosphere more unstable, and if other weather features are in place, thunderstorm development can occur rapidly.

Outflow Boundaries: Cool downdraft air from thunderstorm activity spreads out along the ground and can maintain an identifiable boundary for 12-15 hours. This can result in converging air at the surface forcing thunderstorm development. For this reason, we closely monitor areas where thunderstorms have occurred during the night, and look for any signs of a cool air boundary in the surface data which could set off thunder- storms in the afternoon

Cloud Boundaries: A persistent layer of clouds will retard surface heating. If the cloud edge is well defined, cooler surface air can lie immediately next to much warmer air that has received heating. This temperature difference results in converging and therefore rising air.

Surface Troughs: A trough of low pressure at the surface is an areas where the wind changes direction and speed. This can cause the air to converge (or pile up), which forces the air to rise upward.

Low Level Jet: In the Great Plains, because of the sloping terrain, a nighttime phenomenon occurs where the air accelerates northward between midnight and about 8 am. This lower level acceleration forces air to converge and thus lift upward. This is many times responsible for Minnesota thunderstorms which move in during the late night hours.

The position of many of the features listed above are often mentioned on the NOAA weather radio, and on local TV weather broadcasts. There are numerous other events in the atmosphere which can aid in the development of thunderstorm activity, but are beyond the scope of this reference guide.