Stuve Plots

A Stuve plot is a type of thermodynamic diagram that can be used to determine the potential for convection in the atmosphere. The greater the potential for surface air to rise and upper air to sink, the more severe thunderstorms can be.

What those lines are

Isobars: horizontal lines. These are lines of constant pressure. Any two points at the same vertical height have the same pressure. Since pressure depends principally on altitude, the pressure reading basically tells the altitude. That's why the pressure values decrease as the plot goes up, so higher up on the plot means higher up in the atmosphere.

Isotherms: vertical lines. These are lines of constant temperature. Any two points at the same horizontal position (one directly above the other) have the same temperature. It's hotter to the right, and colder to the left.

Dry adiabats: solid slanted lines. These are the p-T trajectories followed by dry air changing its altitude. Note that temperature decreases as altitude increases, because the expanding air cools. The rate at which the temperature of dry air drops as altitude increases is known as the dry adiabatic lapse rate (DALR), so these lines basically plot the DALR. The numbers printed at the top of these lines at are potential temperature: the temperature, in Kelvin (K), that a dry parcel would have if compressed or expanded adiabatically to 1000 mb.

Saturated adiabats: dashed lines. These are the p-T trajectories followed by saturated air changing its altitude, with water vapor condensing to form liquid water or ice. Note that these do not drop in temperature as quickly as the dry adiabats do, because the condensing water vapor releases heat, warming the air. The rate at which air with water vapor condensing from it drops in temperature as altitude increases is known as the moist adiabatic lapse rate (MALR), so these lines basically plot the MALR. At low pressures and temperatures, the saturated adiabats are very similar to the dry adiabats, because then even saturated air does not contain much moisture.

Saturation mixing ratios: dotted lines. These tell how much water vapor is present in air that is saturated at a given pressure and temperature. Another way to think about this is that they plot how dew point changes with pressure. The numbers printed at the bottom are grams of water vapor per each kilogram of air in the saturated parcel. As the temperature increases, more water vapor is present in a given mass of saturated air. At the pressure and temperature at which moisture first begins to condense from an air parcel, the air is at its dew point. The saturation mixing ratio passing through that point tells the mixing ratio of the parcel. As the pressure drops with altitude, the molecules of water vapor are farther apart, so a lower temperature is required to make them condense. Rising air parcels' *temperatures* do not follow these paths, but their *dew points* do.

Making a Stuve plot

Plot the (T, p) readings from the surface to the lowest pressure (highest elevation) on your axis. This shows the atmosphere's temperature profile with height.

Plot the (T_d, p) dew point readings from the surface to the lowest pressure on your axis. This gives a visual picture of the dew point profile with height. Note that the dew point is never greater than the actual temperature. Where the dew point and actual temperature are the same, there is a cloud.

Go back to the (*T*, *p*) point of the surface temperature reading. With a pencil, very lightly follow along a dry adiabat upward form this point. This tells how the temperature of the parcel will change with altitude before moisture begins to condense from it. There probably won't be a dry adiabat plotted exactly through your starting point, so you will need to artistically guess at its path between the paths of the dry adiabats to the left and to the right.

Go back to the (T, p) point of the surface dew point reading. With a pencil, very lightly follow along a saturation mixing ratio upward form this point. Your plotted line tells how the dew point of the parcel will change with altitude. Again, you will probably need to guess between the plots to the left and right. Continue drawing this line upward until it meets the dry adiabat you drew from the surface temperature reading.

At the point where the two faint pencil lines you have drawn meet, a rising surface parcel's temperature would equal its dew point temperature. This means that moisture would begin to condense at that pressure (altitude). If the parcel were to rise further, its temperature would drop at the saturated adiabatic lapse rate. In terms of this plot, that means it would follow a saturated adiabat from this point upward.

With a plot color, color over the dry adiabat you traced from the surface temperature reading up to the point where it meets the saturation mixing ratio you traced from the surface dew point reading. Above this point, plot along a moist adiabat until the plot leaves the grid. There probably won't be a moist adiabat plotted through the meeting point, so make your artistic guess guided by the moist adiabats to the left and right. The complete path you just plotted shows how the temperature of a parcel of surface air would change if it rose.

Compare the surface parcel's predicted temperature to the actual temperature of the air column over the entire pressure range. At any altitude, if the parcel's temperature is higher than the surrounding air's temperature, it will rise. If it is lower, it will sink. If there is an altitude above which the rising surface air is always warmer than the surrounding air, the potential exists for a thunderstorm. If the air can just make it to that altitude, it will continue to rise without any further energy input.

Ordinarily, in the early morning, the atmosphere will be stable or inverted, so that surface air will not tend to rise. As the ground warms in the Sun, it heats the surface air, which then starts to rise. It stops rising when it reaches the altitude at which its temperature is the same as the temperature of the surrounding air. If, when it rises, the air remains warmer than the surrounding air, it will simply keep rising like a balloon until it reaches the stratosphere. These are the conditions that create cumulonimbus clouds. The greater the temperature difference between the rising warm air and the surrounding cooler air, the more vigorously the air will rise, and the more severe the resulting storm will be.