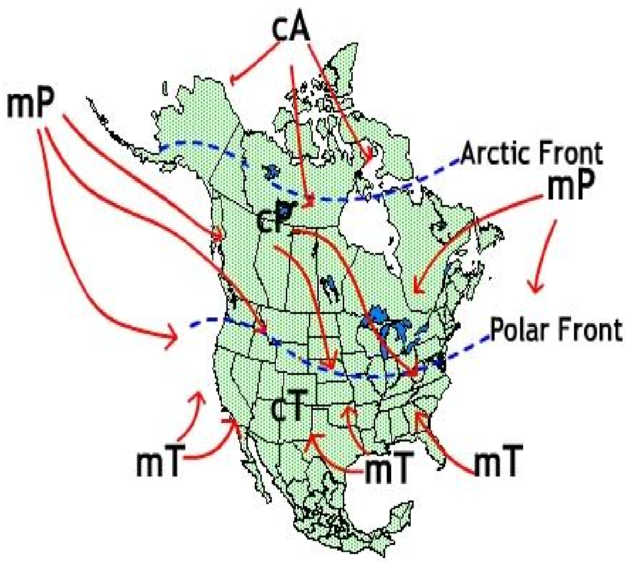
Air Masses and Fronts

Air Masses

The weather of the United States east of the Rocky Mountains is dominated by large masses of air that travel south from the wide expanses of land in Canada, and north from the warm waters of the Gulf of Mexico. Not surprisingly, the term **air mass** means a large body of air (sometimes as large as one million square miles!) that can be characterized by their temperature and humidity. Such large bodies of air form over large portions of the surface of the Earth, and we use the term **source region** to describe the areas of the Earth over which large air masses form.

The diagram below shows the major source regions and air masses for the United States:



Air Masses of North America

In particular, the weather in the midwest and eastern US are predominantly influenced by two of these air masses: the cold, dry air mass coming from Canada, and the warm, moist air mass that forms over the Gulf. The cold, dry Candian air mass is an example of a cP air mass, standing for continental (dry) polar (cold). The warm, moist air that forms over the Gulf and generates almost all of the precipitation over the Eastern 2/3 of the United States is an example of an mT air mass, meaning maritime (moist) Tropical (warm).

Fronts One of the important properties of air is that it is a poor conductor of energy. This means that when two different bodies of air come together, they do not readily mix. Rather, each body of air will retain its individual properties, and a boundary forms between them. When two large air masses meet, the boundary that separates them is called a **front**. Fronts represent fairly abrupt transitions between two large air masses. As you get more and more experienced reading and interpreting weather maps, you will notice that warm, moist air might dominate an area hundreds of miles across, while in another part of the continent a cold, dry air mass holds sway over an equally large region. However, where the two air masses meet, the transition layer between them may be only a few tens of miles across, clearly a sharp transition between two massive bodies of air.

The study of how fronts form and evolve is important, because so much weather and change in weather occurs along these fronts. First, let's review a few the major types of fronts we have studied in class:

Stationary Fronts A stationary front occurs when the frontal boundary between two bodies of air is not moving. This state of affairs will not last long, and the stationary front will soon convert to a warm or cold front. On color weather maps, a stationary front will appear as an alternating series of red semicircles and blue triangles drawn on opposite sides of the frontal boundary

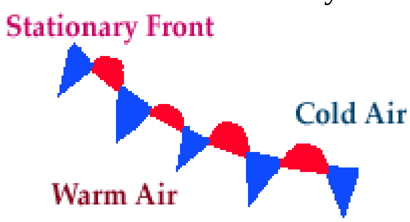


image courtesy University of Illinois WW2010 Project

Along a stationary front, one will observe a significant change of temperatures and shift of winds across the front as shown below

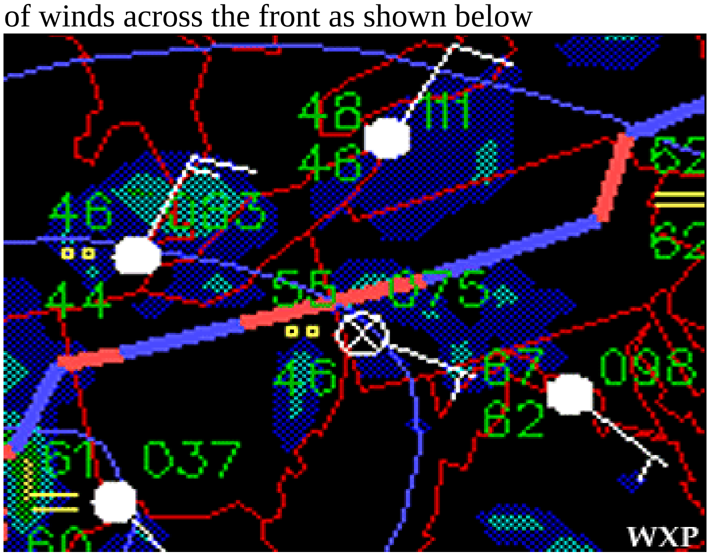


image courtesy Purdue University WXP

Warm Fronts

A warm front occurs when a warm air mass advances and replaces a cold air mass. On a weather map, a warm front is depicted as a red arc, with red semicircles pointing in the direction of the advancing warm air. We can understand the basic weather patterns associated with a warm front by considering the following cross-sectional view:

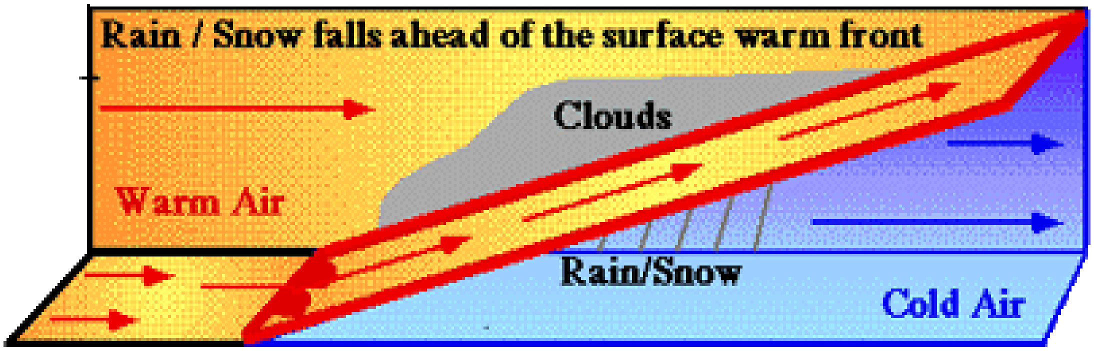


image courtesy NOAA

The warm air is to the left in the image and is moving toward the cold wedge on the right. At this point, it is useful to repeat one of the most important distinctions between warmer and cooler air:**If we consider two air parcels at the same elevation, the warmer air parcel is almost certain to be *less dense* than the cooler air parcel**. Looking at the warm front cross-section, we can then realize that when the warmer air meets the colder wedge, the warm air will glide up and over the cold wedge (a process known as overrunning) because the warmer air is less dense.

This diagram will aid us understand the nature of weather associated with warm fronts. Locations where the warm front has yet to pass lie to the right in this diagram. Clearly, surface readings made in the cold wedge will register cooler temperatures before the warm front passes. By looking at this diagram, we can also determine how surface pressure should vary as the warm front approaches. For this we need to remember two important points: a) pressure is the weight of a column of air, and b) cold air is denser than warm air, in other words, a volume of cold air will contain more mass than an equal volume of warm air (assuming they are at the same height in the atmosphere). Imagine two columns of air above the surface, one far to the right in the diagram, and one just ahead of the warm front. The column of air far to the right (far from the warm front) consists mostly of colder, denser air, with only a small amount of warm air at the top of the column. The column of air just ahead of the warm front consists of very little colder, denser air. Applying what we know about the density of air and the definition of air pressure, we can see that the column of air far from the warm front has greater weight since it has a greater component of colder, denser air. This means that the pressure measured well ahead of the warm front is greater than the pressure just ahead of the front. These facts combine to tell us that **the pressure steadily decreases as a warm front approaches**.

The cross sectional view of the warm front also allows us to envision how and where different clouds will form as the warm front approaches. Remember our class discussions of rising air. We know that rising air cools, and if a parcel of air cools sufficiently, it will cool to its dew point and condense, initiating cloud formation. Since the warmer air glides up along the colder wedge, the warmer (usually moister) air is forced to rise, and condenses to form clouds along the boundary between the two air masses. Imagine an observer far from the warm front. Far ahead of the warm front, the boundary is high above the observer, so any clouds seen will be high and thin, since there is less air at such elevations to produce clouds. As the warm front approaches, the boundary separating the two air masses is closer to the ground, and the clouds form at lower elevations. Thus, an approaching warm front should be accompanied by a progression of cloud cover. The first signs of an approaching warm front are the appearance of high, thin, wispy cirrus clouds. As the front nears, the clouds will become lower in the sky and be thicker, since there will be more air at lower elevations from which to condense clouds. If the front produces precipitation, this will occur in a band just ahead of the front.

After the front passes, it should be obvious that temperatures will rise, pressures will be low and steady, and clouds will dissipate except for the possibility of some fair weather cumulus clouds in the warm sector.

Our study of the wind patterns around a wave cyclone has shown us that the winds ahead of a warm front are from the south or southeast (sometimes the East), and after the warm front passes, winds change direction and come from the south or southwest.

Follow this link to see a very nice and complete table of the weather associated with a warm front passage.

Cold Fronts

A cold front occurs when a mass of cold air advances into a region of warmer air. On weather maps, cold fronts are shown as blue lines with triangles pointing in the direction of the motion of the cold air mass:

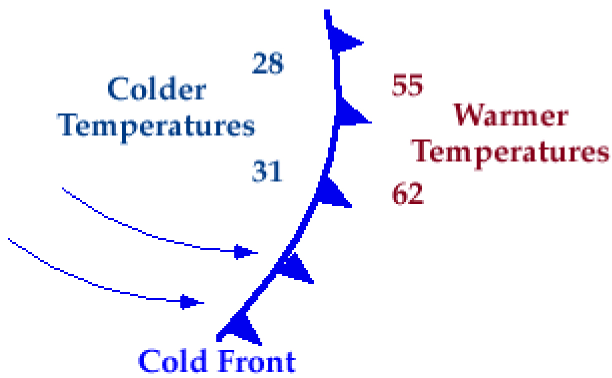
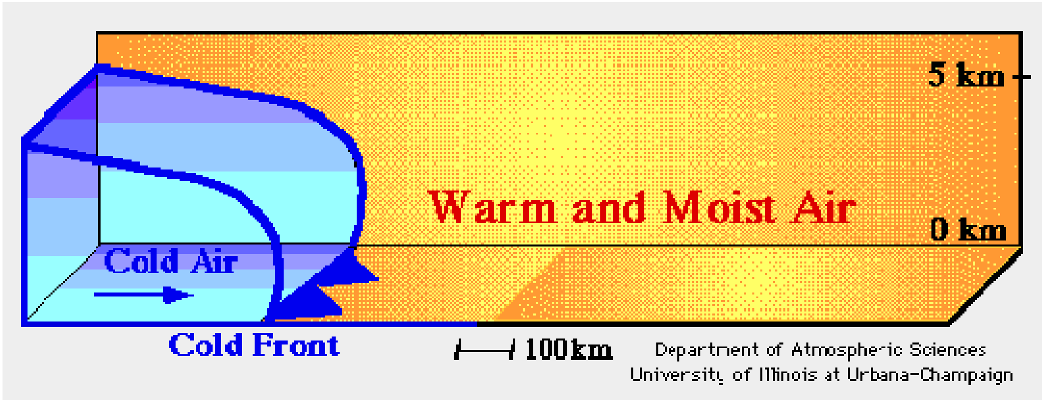


image courtesy University of Illinois WW2010 Project

Recalling again that colder air is denser than warmer air, the cold air will push through the warm air, causing the less dense air to rise:



animation courtesy University of Illinois WW2010 Project

If there is sufficient moisture in the rising warm air, and the convergence of the air masses is energetic enough to lift the warm air high enough, clouds and precipitation can occur in a narrow band just ahead of the cold front. However, it is sometimes the case that the clouds and precipitation "overhang" the front, and there is sometimes precipitation for a short period of time after the cold front passes. More details on the weather associated with a cold front are available here.

Let's look at some weather maps from our past weekend. The maps we looked at in class were actually more complicated than average, requiring more analysis than is associated with beginner's weather maps. Some of the maps of the weekend's weather are a little easier to analyze, and easier to find the position of the cold front (which ultimately gave us some rain this weekend).