Chapter 12
Fronts & Air Masses

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• Air Masses
  o Classification
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Anticyclones or Highs

High pressure centers (highs) are identified as relative maxima in pressure (on constant height maps) or height (on constant pressure maps).

A ridge is an extended area of relatively high pressure (height).

What causes high pressure to occur at the surface?

The mechanisms that lead to the formation of high pressure include:
- the global circulation
- monsoons / seasonal temperature contrasts
- transient weather systems (Rossby waves)
- small scale features (thunderstorms, mountains)

Why are highs observed to tilt west with height?

Winds and advection around surface high

Where is cold (warm) air advection occurring relative to the surface high shown above?

How does the height of upper level pressure surfaces change as the air below warms or cools?
Role of upper level high (ridge) in creating convergence

How does the gradient wind speed compare to the geostrophic wind speed in a ridge (trough)?

As air exits a ridge and moves towards a trough it slows down and convergence occurs.

As air exits a trough and moves towards a ridge it speeds up and divergence occurs.

Convergence occurs ahead of upper level ridges and divergence occurs ahead of upper level troughs.

Air Masses

Air mass: A widespread body of air whose temperature and humidity (and other atmospheric properties) are fairly similar in any horizontal direction at a given altitude

Why are meteorologists interested in air masses?
Air Mass Classification

Air masses are classified based on their temperature and humidity.

The four most common air masses to impact weather in North America are:

- continental polar (cP)
- maritime polar (mP)
- continental tropical (cT)
- maritime tropical (mT)

In the winter continental Arctic (cA) air masses can also impact weather in the United States.

What temperature and moisture characterize these air masses?

Air Mass Source Regions

What features of a source region allow for the formation of air masses?
Transient weather patterns will cause air masses to move out of their source region.

What happens to an air mass once it moves out of its source region?
- modification due to surface fluxes
- modification due to flow over mountains

Air Masses of North America

Continental Polar (cP) and Continental Arctic (cA) Air Masses

Where do cP and cA air masses form?

What are the defining characteristics of cP and cA air masses?

What type of weather is experienced in the mid-latitudes when a cP or cA air mass moves into this region?

How do cP air masses differ between winter and summer?

How do mountains alter the impact of cP and cA air masses?
Maritime Polar (mP) Air Masses

Where do mP air masses form?

What are the defining characteristics of mP air masses?

What type of weather is experienced in the mid-latitudes when an mP air mass moves into this region?

How do mountains alter the impact of mP air masses?

Maritime Tropical (mT) Air Masses

Where do mT air masses form?

What are the defining characteristics of mT air masses?

What type of weather is experienced in the mid-latitudes when an mT air mass moves into this region?
What is the impact of mT air masses originating in the Gulf of Mexico?

What large-scale pressure feature is often responsible for bringing mT air masses into the central and eastern United States?

Continental Tropical (cT) Air Masses

Where do cT air masses form?

What are the defining characteristics of cT air masses?

What type of weather is experienced in the mid-latitudes when a cT air mass moves into this region?
Fronts

**Front:** A boundary (or transition zone) between two air masses of different density

Fronts are characterized by:
- large horizontal temperature gradients
- large horizontal moisture gradients
- strong horizontal wind gradients
- relative minimum in pressure
- clouds and precipitation
- kinks in isopleths (isobars, isotherms) on weather maps

Notice that the fronts shown above separate different air masses and that the fronts are located in areas of relatively low pressure.

What types of fronts are present on the weather map above?
The following symbols are used to indicate fronts on weather maps.

### Fronts move in the direction the frontal symbols point.

In order to locate a front look for:

- Change in temperature
- Change in absolute humidity
- Shift in wind direction
- Pressure and pressure changes
- Cloud and precipitation patterns

#### Stationary Fronts

**Stationary front:** A front with essentially no movement.

**What direction are the surface (upper level) winds relative to a stationary front?**

**What type of weather is associated with a stationary front?**
Cold Fronts

**Cold front:** A front where cold (polar or Arctic) air is advancing and replacing warm (tropical) air.

How will the weather change as a cold front approaches and then passes a given location?

- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?
- How does the pressure change?

Where do clouds and precipitation form relative to a cold front?
Why do clouds and precipitation form along fronts?

What determines how steep a frontal surface will be?

What impact does this have on the distribution of clouds and precipitation associated with the front?

<table>
<thead>
<tr>
<th>TABLE 11.2 Typical Weather Conditions Associated with a Cold Front in Winter in the Northern Hemisphere</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WEATHER ELEMENT</strong></td>
</tr>
<tr>
<td>Winds</td>
</tr>
<tr>
<td>Temperature</td>
</tr>
<tr>
<td>Pressure</td>
</tr>
<tr>
<td>Clouds</td>
</tr>
<tr>
<td>Precipitation</td>
</tr>
<tr>
<td>Visibility</td>
</tr>
<tr>
<td>Dew point</td>
</tr>
</tbody>
</table>

* Tcu stands for towering cumulus, such as cumulus congestus; whereas Cb stands for cumulonimbus. Sc stands for stratocumulus.

The actual weather observed when a cold front passes varies from front to front and can also differ regionally.

**Backdoor cold front:** A cold front that moves into an area from the east or northeast

**Cold air damming:** Cold air that gets trapped near the surface by mountains
Warm Fronts

**Warm front:** A front where warm (tropical) air is advancing and replacing cold (polar or Arctic) air

How will the weather change as a warm front approaches and then passes a given location?
- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?
- How does the pressure change?

How does the speed of movement of a warm front compare to that of a cold front?

Why does the speed differ between these types of fronts?
How does the slope of a warm front compare to the slope of a cold front?

Where do clouds form relative to a warm front?

**Overrunning:** Warm, less dense air rising over cold air

Why does a frontal inversion exist ahead of the warm front?

Would you expect a frontal inversion to be associated with a cold front?

How does the wind direction change with height ahead of a warm front?

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<table>
<thead>
<tr>
<th>WEATHER ELEMENT</th>
<th>BEFORE PASSING</th>
<th>WHILE PASSING</th>
<th>AFTER PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winds</td>
<td>South or southeast</td>
<td>Variable</td>
<td>South or southwest</td>
</tr>
<tr>
<td>Temperature</td>
<td>Cool to cold, slow warming</td>
<td>Steady rise</td>
<td>Warmer, then steady</td>
</tr>
<tr>
<td>Pressure</td>
<td>Usually falling</td>
<td>Leveling off</td>
<td>Slight rise, followed by fall</td>
</tr>
<tr>
<td>Clouds</td>
<td>In this order: Ci, Cs, As, Ns, St, and fog; occasionally Cb in summer</td>
<td>Stratus type</td>
<td>Clearing with scattered Sc, especially in summer; occasionally Cb in summer</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Light-to-moderate rain, snow, sleet, or drizzle; showers in summer</td>
<td>Drizzle or none</td>
<td>Usually none; sometimes light rain or showers</td>
</tr>
<tr>
<td>Visibility</td>
<td>Poor</td>
<td>Poor, but improving</td>
<td>Fair in haze</td>
</tr>
<tr>
<td>Dew point</td>
<td>Steady rise</td>
<td>Steady</td>
<td>Rise, then steady</td>
</tr>
</tbody>
</table>
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Fronts and the Jet Stream

The large temperature gradient associated with fronts indicates that there is a large thermal wind effect near fronts.

As a result the polar jet stream is located above fronts.

Frontogenesis

**Frontogenesis**: A strengthening of a front as the temperature contrast across the front increases

**Frontolysis**: Weakening or dissipation of a front as the temperature contrast across the front lessens

What processes lead to frontogenesis (frontolysis)?
- kinematics
- thermodynamics
- dynamics
Drylines

**Dryline**: A boundary that separates moist (maritime) and dry (continental) air

Where in the United States are drylines most often observed?

Occluded Fronts

**Occluded front**: A front that forms when a cold front catches up to and overtakes a warm front

What causes a cold front to catch up to a warm front?
Cold occlusion: An occluded front with colder air behind the occluded front

How does the weather change as a cold occluded front approaches and passes a given location?

- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?
- How does the pressure change?
Warm occlusion: An occluded front with colder air ahead of the occluded front

How does the weather change as a warm occluded front approaches and passes a given location?
- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?
- How does the pressure change?

What are the differences between a cold and warm occluded front?
- How does the position of the upper level front differ?
- How does the temperature differ across these types of fronts?

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<thead>
<tr>
<th>WEATHER ELEMENT</th>
<th>BEFORE PASSING</th>
<th>WHILE PASSING</th>
<th>AFTER PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winds</td>
<td>East, southeast, or south</td>
<td>Variable</td>
<td>West or northwest</td>
</tr>
<tr>
<td>Temperature</td>
<td>Cold or cool Cold</td>
<td>Dropping Rising</td>
<td>Colder, Mild/h</td>
</tr>
<tr>
<td>(a) Cold-type occluded</td>
<td>(b) Warm-type occluded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>Usually falling</td>
<td>Low point</td>
<td>Usually rising</td>
</tr>
<tr>
<td>Clouds</td>
<td>In this order: Ci, Cs, As, Ns</td>
<td>Ns, sometimes Tcu and Cb</td>
<td>Ns, As, or scattered Cu</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Light, moderate, or heavy precipitation</td>
<td>Light, moderate, or heavy continuous precipitation or showers</td>
<td>Light-to-moderate precipitation followed by general clearing</td>
</tr>
<tr>
<td>Visibility</td>
<td>Poor in precipitation</td>
<td>Poor in precipitation</td>
<td>Improving</td>
</tr>
<tr>
<td>Dew point</td>
<td>Steady</td>
<td>Usually slight drop, especially if cold-occluded</td>
<td>Slight drop, although may rise a bit if warm-occluded</td>
</tr>
</tbody>
</table>
Upper-Tropospheric Fronts

Upper-tropospheric (or upper level) front: A front that is present aloft that may or may not extend all the way to the surface

What is the relationship between upper air fronts, the tropopause, and polar jet stream?

Where is air rising (sinking) relative to the upper air front and jet stream?