ESCI 241 – Meteorology
Lesson 15 – Air Masses and Fronts
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Reading: Ahrens, Chapter 12

AIR MASSES

- **An *air mass* is defined as a large body of air that has a fairly uniform horizontal distribution of temperature and moisture content.**
- **Air masses are at least around 1000 miles in horizontal extent.**
- **The temperature and moisture content of an air mass are not exactly uniform, but the horizontal gradients of these variables are small.**
- **The region where an air mass is formed is called the *source region*.**
- **In order to form, and air mass must remain in its source region for a week or more.**
- **Source regions must be large and uniform.**
- **Air masses are associated with anticyclones (areas of high pressure).**
- **The major source regions for air masses are either found in the tropics or in the polar regions.**

AIR MASS CLASSIFICATION

- **Air masses are classified according to the latitude of their source region, and according to whether they are formed over land or over water.**
- **Latitude of source region**
  - **Arctic**
  - **Polar**
  - **Tropical**
- **Air masses formed over water are called *maritime* air masses.**
- **Air masses formed over land are called *continental* air masses.**
- **The five categories of air masses are**
  - **continental arctic – *cA***
  - **continental polar – *cP***
  - **continental tropical – *cT***

- **maritime tropical – *mT***
- **maritime polar – *mP***

AIR MASS MODIFICATION

- **Once an air mass moves out from its region of origin, it can become modified by the surface over which it is passing.**
- **If an air mass is colder than the surface over which it is passing it receives the designation, *k*.**
- **If an air mass is warmer than the surface over which it is passing it receives the designation, *w*.**
- **For example, if a continental polar air mass (cP) moves out over the warm water, it becomes (cPk).**
- **An air mass's stability can be assessed by weather it is colder or warmer than the surface over which it is passing.**
  - **Cold air over a warm surface will be unstable**
  - **Warm air over a cold surface will be stable**
- **A *k* air mass will often be associated with cumuliform clouds**
- **A *w* air mass will often be associated with stratiform clouds**
- **An air mass can be modified so much that it becomes an entirely different air mass type.**
- **A cP air mass moving out over the water will eventually become an mP air mass.**

PROPERTIES OF NORTH AMERICAN AIR MASSES

- **Continental Polar (cP)**
  - **Forms over Canada and Alaska**
  - **Cold and dry**
  - **Stable**
  - **Dominant air mass over central and eastern U.S. in Winter.**
  - **Brings cool sunny days, and clear, cold nights.**
  - **In summer it brings temporary relief from hot, humid weather.**
  - **rarely reaches west of the Rocky Mountains**

- **Continental Arctic (cA)**
  - **Forms over Arctic Basin and Greenland icecap**
  - **Similar to cP air mass, but colder and drier**
  - **Very cold and dry**
  - **Stable**
  - **Only reaches central and eastern U.S. in fall, winter, or spring.**
  - **rarely reaches west of the Rocky Mountains**
- **Maritime Polar (mP)**
  - **Formed over the oceans at high latitudes**
  - **cool and humid (not as cold as cP)**
  - **Affects west coast of U.S. year round, especially Northern California, Oregon, and Washington.**
  - **This is why the summers on the West Coast of the U.S. are mild, or even chilly.**
  - **Brings rain and clouds to West Coast during winter.**
  - **Only rarely affects the Northeast U.S.**
  - **In winter it is responsible for the *nor'easters*, with lots of snow, sleet, or freezing rain.**
  - **In summer, it brings very pleasant weather to New England.**
- **Maritime Tropical (mT)**
  - **Originates over the tropical oceans.**
  - **Hot and humid**
  - **Responsible for the majority of precipitation over central and eastern U.S.**
  - **Dominant air mass over central and eastern U.S. in the summertime**
  - **Brings hot, sticky weather**
  - **Becomes very unstable as it moves over hot land, frequently resulting in afternoon thunderstorms**
  - **Occasionally affects central and eastern U.S. in wintertime, producing lots of precipitation as it is forced to rise over cP air.**

- **mT air occasionally affects southern California , Arizona, Nevada, and Utah in the winter, bringing heavy rain to these areas.**
- **mT air also is brought into Arizona during the North American monsoon.**

- **Continental Tropical (cT)**
  - **Only source that affects U.S. is in Northern Mexico and the desert southwest of U.S.**
  - **Hot and dry**
  - **Unstable, but little moisture, so few clouds and no precipitation.**

LAKE EFFECT SNOW

- **Occurs when cP or cA air masses move over warm water and then over opposite shore.**
- **Air picks up moisture from water.**
- **It is also heated from below, which makes it unstable**
- **Speed convergence (due to increased friction over land) enhances upward motion, and intensifies the snow showers.**
- **Brings heavy snow showers along leeward lakeshore.**

FRONTS

- **A *front* is a boundary between two air masses.**
- **General properties of fronts**
  - **Sharp temperature contrast**
  - **Moisture contrast**
  - **Cyclonic wind shift**
- **Because of the two air masses have different temperatures and different humidities they are of different density.**
  - **The lighter air mass will *overrun* the denser air mass, which causes lifting along the frontal zone. This is why fronts are associated with clouds and precipitation.**

- **Because air masses are associated with areas of high pressure, and fronts separate these air masses, fronts themselves lie in regions of low pressure, or troughs.**

WARM FRONTS

- **Warm air advances into region formerly covered by cold air.**
- **Weather map symbol is red line with circular teeth.**
- **Warm air rides up and over cold air.**
- **The frontal surface slopes very shallowly with height (about 1:200).**
- **The front moves forward at 15 - 20 mph.**
- **Cloud sequence**
  - **Cirrus**
  - **Cirrostratus (possibly cirrocumulus)**
  - **Altostratus**
  - **Nimbostratus (sometimes with embedded cumulonimbus)**
- **Precipitation**
  - **Steady rain, drizzle, or snow**
  - **Freezing rain or sleet may occur on cold side of front**

COLD FRONT

- **Cold air advances into region formerly covered by warm air.**
- **Weather map symbol is blue line with triangular teeth.**
- **Warm air rides up and over cold air.**
- **The frontal surface has a steeper slope than a warm front (about 1:100)**
- **The front moves forward at 20 - 35 mph (much faster than warm front).**
- **Cloud sequence**
  - **Cirrus and cirrostratus (from thunderstorm anvils)**
  - **Altocumulus (sometimes)**
  - **Cumulonimbus**
- **Precipitation**
  - **Showers of rain or snow**

- **Often thunderstorms**

- **Precipitation region is much narrower with a cold front than with a warm front.**
- **Precipitation region can be either ahead of or behind cold front.**
- **Additional classification of fronts**
  - ***Anafront* – Warm air ascends over cold air**
    - **Precipitation usually to rear of front**
  - ***Katafront* – Warm air descends down frontal surface**
    - **Precipitation usually ahead of front**
    - **May have squall line well ahead of front**

STATIONARY FRONT

- **Boundary between air masses is not moving**
- **Weather map symbol is alternating red and blue line with alternating warm and cold front teeth pointing in opposite directions.**
- **Even though frontal boundary itself doesn't move, the warm air is still moving up and over the cold air.**
- **Clouds associated with stationary fronts are usually stratiform (stratus, nimbostratus, altostratus, cirrostratus).**
- **Precipitation is usually light to moderate, and steady (rain or snow).**
- **Stationary fronts can linger for days, causing prolonged periods of dreary weather.**

OCCLUDED FRONTS

- **Occur when a cold front overtakes a warm front**
- **Weather map symbol is a purple line with both sharp and circular teeth pointing in the same direction.**
- **Types of occlusions**
  - **cold occlusion – air behind cold front is colder than air ahead of warm front**
  - **warm occlusion – air behind cold front is warmer than air ahead of warm front**

- **Clouds associated with occluded fronts are a complicated mixture of those associated with warm and cold fronts.**

DRY LINES

- **Not all fronts are associated with a temperature contrast. Some are only associated with a humidity contrast (*remember that moist air is lighter than dry air*).**
- **A *dry-line* front often forms in the West Texas, Oklahoma Panhandle, and Western Kansas region, and is a boundary between cT and mT air masses.**
- **This dry-line front spawns thunderstorms and tornadoes in this region.**

MORE ABOUT FRONTS

- **In general, the faster a front moves, the more severe the weather will be (which is why cold fronts are more violent than warm fronts).**
- **The sharper the temperature contrast across the front, the more severe the weather will be.**
- **Sometimes, fronts are dry, meaning that even though there is uplifting along the front, there is not enough moisture to cause clouds or precipitation.**
- **In the eastern U.S.**
  - **Most cold fronts are between cP and mT air masses.**
  - **Most warm fronts are between cP and mT air masses, or sometimes between mP and mT air masses (such as in a nor'easter).**
- **In the summer, sometimes the temperature contrast across the front is not very great. This is what the T.V. meteorologists sometimes call a *cool front*, but technically it is still a cold front.**

LOCATING FRONTS ON WEATHER MAPS

- **Look for**
  - **A cyclonic shift in the wind direction between two weather reporting stations**
  - **A strong temperature contrast between two weather reporting stations**
  - **A dew-point contrast between two weather reporting stations**

- **A low pressure trough**

- **Fronts are associated with a tight temperature gradient**
  - **The isotherms or thickness lines will be tightly packed near frontal zone**
  - **Packing will be greatest on cold side of front**
- **Pressure tendency useful.**
  - **Falling pressure means front hasn't yet passed**
  - **Rising pressure means front has passed.**
- **Satellite and radar images are often useful for locating fronts**