Chapter 8
Air Masses
1. An **Air Mass** is a large body of air usually about 1500 km across and several km thick, that has homogeneous physical properties.

2. The important physical properties are temperature & moisture content

3. An air mass moves as a whole over large distances

4. The air mass is modified as it moves, and modifies the local weather
Air Masses - 2

1. Air masses can take several days to move through a given location, and since they have uniform properties the weather will be very similar throughout that time - *air-mass weather*.

2. The areas in which air masses originate are called *source regions*. 
Air Masses - 3

1. To be a source region, the region must be **extensive & physically uniform**, and **general stagnation** of the atmosphere must exist so that the air mass will stay in its source region long enough to come to some measure of equilibrium with the surface.
Sonoran desert – source region for CT air masses
Canadian Tundra—source region for cold dry air masses
Maritime source region
1. **Major air masses** affecting the US are
cA - continental arctic
cP - continental polar
cT - continental tropical
mP - maritime polar
mT - maritime tropical
2. c & m describe the surface over which the air mass forms
3. mA is not encountered very often
(a) Winter pattern
(b) Summer pattern
1. Major source regions are *not found in mid-latitudes* - because there is too much variability in the weather (cyclones etc.)
2. Differences between polar & Arctic are not major.
3. Maritime air masses tend to have a higher moisture content than continental
Air-Mass Modification

1. Air masses are modified as they travel by (a) heating or cooling from below, (b) addition or loss of moisture, and (c) vertical movements within the air mass.

2. When continental air masses move over water, they gain moisture, and become unstable because of heating by the warmer sea, and becomes an mP air mass.
1. Warm air masses are cooled from below and are stable. Get cirrus clouds. Because there is no vertical motion, smoke & dust are concentrated in the lower layers.

2. Vertical movements can be induced in the air masses by geography, cyclones, and anticyclones - called *mechanical or dynamic*. 
Properties of North American Air Masses
<table>
<thead>
<tr>
<th>Air Mass</th>
<th>Source Region</th>
<th>Temperature and Moisture Characteristics in Source Region</th>
<th>Stability in Source Region</th>
<th>Associated Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>cA</td>
<td>Arctic basin and Greenland ice cap</td>
<td>Bitterly cold and very dry in winter</td>
<td>Stable</td>
<td>Cold waves in winter</td>
</tr>
</tbody>
</table>
| cP      | Interior Canada and Alaska | Very cold and dry in winter | Stable entire year | a. Cold waves in winter  
b. Modified to cPk in winter over Great Lakes bringing “lake-effect” snow to leeward shores |
| mP      | North Pacific | Mild (cool) and humid entire year | Unstable in winter  
Stable in summer | a. Low clouds and showers in winter  
b. Heavy orographic precipitation on windward side of western mountains in winter  
c. Low stratus and fog along coast in summer; modified to cP inland |
| mP      | Northwestern Atlantic | Cold and humid in winter  
Cool and humid in summer | Unstable in winter  
Stable in summer | a. Occasional “nor’easter” in winter  
b. Occasional periods of clear, cool weather in summer |
| cT      | Northern interior Mexico and southwestern U.S. (summer only) | Hot and dry | Unstable | a. Hot, dry, and cloudless, rarely influencing areas outside source region  
b. Occasional drought to southern Great Plains |
| mT      | Gulf of Mexico, Caribbean Sea, western Atlantic | Warm and humid entire year | Unstable entire year | a. In winter it usually becomes mTw moving northward and brings occasional widespread precipitation or advection fog  
b. In summer, hot and humid conditions, frequent cumulus development and showers or thunderstorms |
| mT      | Subtropical Pacific | Warm and humid entire year | Stable entire year | a. In winter it brings fog, drizzle, and occasional moderate precipitation to N.W. Mexico and S.W. United States  
b. In summer this air mass occasionally reaches the western United States and is a source of moisture for infrequent convectional thunderstorms. |
cP and cA Air Masses

1. cP air masses originate in the snow regions of Canada & Alaska, poleward of 50°N.
2. cA forms further north, over the Arctic basin & the Greenland icecap, mainly in winter.
3. During the winter, the Earth loses more energy than it receives from the sun, and the air near the ground (below about 1 km) becomes very cold, and colder than the air higher up. This temperature inversion leads to marked stability (which is required for an air mass to form)
1. This very cold & very dry air sweeps down to the Gulf of Mexico, because there are no major barriers.

2. cP also influences summer weather, but not as drastically.

3. In summer, cP air is heated from the ground, because of the solar heating.

4. Summer cP air is moister and warmer than winter cP air, but it is still cool and dry relative to the ground it passes over. Provides relief.
Lake-Effect Snow - Cold Air over Warm Water

1. Highly localized snow storms occurring along the leeward shores of the Great Lakes (+others).

2. Buffalo & Rochester in upper NY state get most snow

3. **Cause** - in summer, the lakes absorb a huge amount of heat. Land cannot store heat as effectively. As autumn & winter arrive, the land cools must faster than water. Water is typically 8°C warmer than the land in the south, and 16°C in the north.
**TABLE 8-2 Monthly Snowfall at Thunder Bay, Ontario, and Marquette, Michigan**

<table>
<thead>
<tr>
<th></th>
<th>Thunder Bay, Ontario</th>
<th></th>
<th>December</th>
<th></th>
<th>January</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>3.0 cm (1.2 in.)</td>
<td>14.9 cm (5.8 in.)</td>
<td>19.0 cm (7.4 in.)</td>
<td>22.6 cm (8.8 in.)</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
<td>56.4 cm (22.0 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td></td>
<td></td>
<td></td>
<td>53.1 cm (20.7 in.)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Marquette, Michigan</th>
<th></th>
<th>December</th>
<th></th>
<th>January</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>5.3 cm (2.1 in.)</td>
<td>37.6 cm (14.7 in.)</td>
<td>56.4 cm (22.0 in.)</td>
<td>53.1 cm (20.7 in.)</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>December</td>
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<tr>
<td>January</td>
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</tbody>
</table>
Lake-Effect Snow - 2

1. Temperature difference can reach 25°C when a cP or cA air mass moves over the lakes.
2. The cP or cA air masses acquire large amounts of heat and moisture from the water in the lakes. Air mass becomes much warmer than the lake shore.
3. When the air arrives at the shore, it is humid and unstable, resulting in snow showers.
mP Air Masses

1. Form over oceans at high latitudes, cool to cold & humid.
2. Mild compared with cP and cA, since they form over water rather than land.
3. Sources of mP that affect America are (1) the north Pacific, and (2) N.W. Atlantic from Newfoundland to Cape Cod.
4. *Pacific mP air masses* in winter start out as cP air in Siberia as a cold, dry & stable air mass.
cP
Cold, dry, stable

Modified cP
Cool, less dry, stable

mP
Cool, moist, unstable
1. Flow over relatively warm sea causes warming & evaporation from the sea water, making the air warm and moist.
2. When they reach the US, the air masses form clouds and bring shower activity at the coast.
3. As the air moves inland, the mountains cause orographic lifting, which causes rain & snow on the western (windward) side of the mountains.
4. In summer, mP air flows over water that is cooler than the land.
1. The Pacific anticyclone (high pressure, clockwise flow of air) directs a southward flow of cool air.

2. Results in low stratus clouds and coastal fogs.

3. The cool air is warmed as it moves east over land, so the RH decreases and the air becomes dry.

4. *N.W. Atlantic mP air masses* move east, away from US towards Europe (general eastwards movement of weather events)
mP Air Masses - 4

1. Usually do not affect the US in winter, except when the northern or northeastern US is on the northern or northwest edge of a low-pressure cyclonic region.

2. Anticlockwise flow around the cyclone draws in the cold mP air into the US, generally from the NE - called *nor'easter*.

3. Affect areas east of Appalachians and north of Cape Hatteras (NC).
*Storm not drawn to scale. Usually, a nor’easter will encompass much of the east coast. I have drawn this to show you it’s effect on Massachusetts.

http://www.explore-massachusetts.com/noreaster.html

NOAA GOES-east satellite image of water vapor, the morning of April 16, 2007
1. Get strong (cold) winds, temperatures near 0C, high RH & precipitation.
2. In the summer, cool air is welcomed.
3. The southern part of the NW Atlantic high (high pressure, clockwise flow of air) that exists during the summer brings cool easterlies into New England and locations further south.
Properties of North American Air Masses
MT produces clouds
mT Air Masses

1. Originate over Gulf of Mexico, Caribbean sea, and western Atlantic ocean.
2. Also from eastern tropical Pacific, but these have little effect.
3. mT air masses are warm to hot, humid, and often unstable.
4. mT air masses are an important way by which heat from the tropics can move polewards.
mT Air Masses - 2

1. *North Atlantic mT* air masses (includes Caribbean & the Gulf) are located on the weak western side of the subtropical high (anticyclone), where subsidence is weak.

2. These air masses are the primary source of precipitation in the eastern 2/3 of the country (west of the Rockies, which drain the moisture from air masses coming from the west coast.)

3. mT air masses are neutral or unstable.

4. During winter, cP air usually dominates the mT air over central & eastern US.
mT Air Masses - 3

1. Sometimes, however, mT wins the battle and invades the US. The warm air is chilled & stabilized as it moves north. (Now have mTw)

2. Widespread precipitation occurs when the warm air mass is pulled into a travelling cyclone, and forced to ascend.

3. mT air masses from the Gulf are the cause of most wintertime precipitation over eastern and central states.

4. Dense fogs also result.
1. In *summer*, the air masses from the Gulf, the Caribbean & northern Atlantic are more abundant than in winter.

2. Dominate the weather east of the Rockies.

3. Monsoonal flow (sea to land) sends warm, moist air deep into the continent. Gives rise to hot & humid weather in eastern & southern US.

4. Flow is mT\textsubscript{k} (cool air over warmer land), and air is unstable, especially during the day (land is hotter).
mT Air Masses - 5

1. Only a small amount of lifting is needed to bring about active convection, cumulus clouds & thunderstorms or showers.

2. *Isohyets* are lines connecting places with equal rain fall. (Fig 8.9)

3. *North Pacific Maritime Air* has much less effect than mT from the Gulf etc.

4. In *winter*, only NW Mexico and SW US are affected.
Average annual precipitation
1. Because the source region lies along the eastern side of the Pacific anticyclone, subsidence aloft produces upper-level stability. As the air mass moves northward, cooling at the surface increases stability.

2. In summer, the mT air moves northwards up the Gulf of California and into the interior of the western US.

3. Summer heating of the land produces a low, into which the moist mT air flows.

4. SW locations get most rain in July & Aug.
(b) Summer pattern
CT Air Masses

1. US narrows towards the south, so there are no extensive source regions for cT air masses.
2. In *summer*, the northern part of interior Mexico and adjacent parts of the US SW produce hot & dry cT air.
3. Air is unstable, but has extremely low humidity, so no clouds or precipitation.
End Chapter 8

Chapter 8 Homework: GIST: 1, 2, 4