ATMOSPHERE: WEATHER PATTERNS AND STORMS

I. AIR MASSES

A. General

1. Air Mass - immense body of air, characterized by homogeneity of temperature and moisture at any given altitude
   a. 1000 miles or more in breadth
   b. Passes through area over the course of days
      (1) e.g. Summer: heat wave, high temps, high humidities
         (a) ends with series of thunderstorms and few days of cooler weather
      (2) e.g. Winter: frigid clear, subzero cold spell
         (a) ends with thick stratus clouds, rising temps. and snowfall.

2. Front: boundary between two adjoining air masses having contrasting characteristics
   a. passage of a front marks a change in weather

B. Source Regions

1. Source Region: area of earth's surface over which air masses assume their distinguishing characteristics
2. Types of Air Masses
   a. Classified According to Latitude and Temperature
      (1) Polar (P) air masses
         (a) originate in high latitudes
         (b) cold air mass temps.
      (2) Tropical (T) air masses
         (a) originate in low latitudes
         (b) warm air mass temps
   b. Classified According to Geographic Source and moisture
      (1) Continental (C) designates land source
         (a) On the dry side
      (2) Maritime (M) designates ocean/water source
         (a) On the wet side

   c. Four Basic Types of Air Masses
      (1) Continental Polar
         (a) On dry and cold side
      (2) Continental Tropical
         (a) On dry and warm side
      (3) Maritime Polar
         (a) On wet and cold side
      (4) Maritime Tropical
         (a) On wet and warm side

C. Weather Associated with Air Masses

1. Relationships in U.S. East of Rockies (most influenced by Cp and Mt)

a. Continental Polar Masses
(1) Originate in northern Canada, AK and Arctic
(2) Cool and Dry Air
(3) High Pressure, few clouds
(a) Winter: clear cold arctic air
(b) Summer: clear cool air

(4) Local Effects
(a) Great Lakes
i) "Lake Effect"
a) winter: cold arctic air, over warmer moisture air above Great Lakes
b) Lee side of lakes = wet, humid unstable air.... snow showers, heavy accumulation (Buffalo, Erie, etc.)

b. Maritime Tropical Air Masses
(1) Originate in Gulf of Mexico, Caribbean/Atlantic
(2) Warm, moisture laden, unstable
(3) Responsible for most of rain in eastern 2/3's of US
(a) Summer: Mt into central and east US
i) heat, high humidity

2. Pacific Northwest
a. Heavily influenced by Maritime Polar air masses from NW in Pacific
b. west side Cascade/orographic rainfall

3. Southwest
a. Continental Tropical Air
(1) Dry, warm, arid
(2) locally contained to Southwest

4. New England
a. Northeaster
(1) maritime polar air mass from northeast off N. Atlantic
(a) snow and frigid temps

II. FRONTS
A. General
1. Fronts- boundaries that separate air masses of different densities
a. one warmer and often higher in moisture
b. avg. 15-200 km wide, narrow compared to breadth of air mass

2. Vertical Configuration
a. Warm air: less dense
(1) warm air over cold air (more dense)
(2) warm air/cold air interface often sloping/wedge shaped at low angle
b. Fronts often collisional in nature
c. Always warm air forced aloft, with colder bottom air acting as a wedge

B. Warm Fronts
1. warm air moves over wedge of cold air
a. map symbol: line with semi-circles extending into cold air
2. Average slope of warm front: 1:200 (V:H)
3. Ascending Warm Air
a. cooling by adiabatic expansion
b. often clouds and precipitation
(1) several hours of gentle precipitation over large region
(a) gentle slope of front does not encourage convective activity
c. Increase in temperature

C. Cold Fronts
1. cold air moves into region of warm air
a. map symbol: line with triangular barbs extending into warm air
2. Average slope of cold front: 1:100 (V:H)
a. steeper than that of warm front
b. cold fronts in general advance more rapidly than warm fronts

3. Actively forces warm air aloft
a. cold fronts produce more violent weather
(1) sudden downpours
(2) wind gusts
(3) >intensity, < duration compared to warm front

4. Behind Front
a. cold air mass, subsiding air
b. Often clear and cold behind the front

D. Occluded Fronts
1. Cold front over takes a warm front
2. Wedging of warm air aloft between two cold air masses
3. Complex weather patterns/ heavy or light rain possible

III. MIDDLE LATITUDE WAVE CYCLONES (LOW PRESSURE SYSTEMS)
A. General
1. At Middle Latitudes (Like U.S.)
a. Cold and Warm Front Activity Commonly Associated with Low Pressure Systems
(1) Cyclone = low pressure system, counterclockwise rotation
(a) Common Harbringer of Rainfall to Central and Eastern U.S.
(2) "Wave" Cyclone- refers to a low pressure system comprised of cold and warm air, with the front commonly bending into a swirling low pressure system

B. Role of Upper Level Jetstream in Maintaining Low Pressure System
1. Cyclone: low pressure system with converging air drawn inward
a. with inward flow, if there were no mechanism for air escape, the low pressure area would eventually "fill up" with converging air and cease to exist

(1) However, we know that low pressure systems can exist for low periods of time, migrating across U.S.

2. Upper level air flow
   a. With converging air into low pressure system, air is piped to higher altitudes aloft, where it escapes the low pressure zone into the upper jetstream
      (1) "piping" of air through the low to the jet stream allows low pressures to be maintained in the cell over longer periods of time
         (a) otherwise the cell would "fill up" and the pressure would rise

   b. Air flow aloft also helps direct and mobilize cyclonic systems through shear flow

3. Moral of the story: air flow aloft, is important in maintaining and influencing lower level weather patterns

IV. THUNDERSTORMS

A. Thunderstorms
   1. lightening, thunder, localized intense rain fall, high energy events
   2. associated with billowing cumulonimbus clouds

B. Formation and Associations
   1. T-storms associated with cumulonimbus clouds
      a. U.S. common associated with Mt air masses derived from Gulf of Mexico and migrate northward
      b. Also: associated with cold fronts and forcful lifting of unstable air

   2. Process
      a. warm moist air lifted aloft
         (1) heat loss and instability with > altitude
         (2) common in afternoon and early evening at max. surface temperatures

      b. Towering cumulonimbus clouds
         (1) upward of 12,000 m in height
         (2) requires continual supply of warm moist air
            (a) cumulative effect to reach great heights
         (3) strong updrafts up to 62 mph
         (4) at point of moisture/drops > updrafts = cloud burst of rain
            (a) upon release of moisture: strong downdrafts, wind gusts, intense rainfall
            (b) life of cumulonimbus clouds ~1 hour between origination and down pour
      c. Lightening
         (1) cloud discharge of electricity
            (a) Process
               i) associated with movement of precipitation in cloud

ii) Charge accumulation
a) Upper portion of cloud = positive charge
b) lower poriton of cloud = negative charge
c) charges build to millions/hundreds of millions of volts before lightening is discharged

iii) Discharge/lightening
a) charge buildup until discharge
b) rapid multiple strokes of electrical charge from cloud to ground or from cloud to cloud
c) 1/10th of sec. to discharge lightening bolt

(2) Thunder
(a) lightening---rapid heating of air upon passage----violent expansion of superheated air
i) explosive air expansion = thunder
(b) "heat lightening" = lightening occurring too far away to hear thunder (>20 km)

V. TORNADOES
A. Tornado =
1. local storm of short duration
2. violent wind storm emanating from a funnel-shaped spiraling column of air
3. Low pressure centers, up to 10% lower than outside column
4. Rapid convergence of air to low pressure center
a. swirling inrushing air
b. high pressure gradients = air flow up to 300 mph
5. tied to cumulonimbus cloud, form in association with thunderstorms
6. Dimensions/velocity
a. D = 500-2000 Ft, Vel up to 28 mph
b. Tornado tracks up to 16 miles long

B. Frequency and Occurrence
1. dominant in U.S. in April through June
2. Avg. 780/yr in U.S.
3. Tstorms and tornadoes commonly associated with middle-latitude cyclone development from above
a. Cp air from canada mixing with Mt air from Gulf of Mexico
(1) intense temp. differences
(2) commonly meet in central U.S.
(3) most common point of occurrence for Tstorms and tornadoes

VI. HURRICANES
A. Hurricanes- whirling tropical cyclones with wind speeds up to 185 mph
1. highly destructive because of high winds in coastal areas
2. may form 50 "storm surge" waves
B. Character
1. Form in tropical waters between 5 and 20 Latitude
a. Atlantic = "Hurricanes"
(1) U.S. avg. = 5/yr

b. Pacific = "typhoons"
(1) N. Pacific highest no. of occurrence =20/yr
c. Indian = "Cyclones"

2. Characteristics
a. wind speed = > 74 mi/hr
b. rotary counterclockwise circulation
c. Dimensions
(1) D=375 mi
(2) Height = up to 40,000 Ft altitude

d. Low pressure centers
(1) outside press. - inside press. = 60 millibars
(2) steep pressure gradient
(3) inward, converging, spiraling winds

e. Upper level air flow
(1) divergent and outward, maintaining the low pressure center of the storm

3. Morphology
a. Eye of Hurricane
(1) low pressure center of cyclone
(a) avg. 12 mile in Diameter
(b) zone of calm and scattered clould cover
(c) warm zone

b. swirling rotation of storm function of coriolis effect

4. Process
a. Hurricane = heat energy built up and liberated by release of water vapor
b. hurricanes form over oceans in late summer, with abundant warm moist air plentiful
(1) water temps to 80 F, warm moist overlying air
(2) can not form in cool water temps, hence limited latitudinally
c. Storm Progression
(1) Tropical depression- cyclone with wind speed < 38 mi/hr
(2) Tropical Storm- cyclone with wind speed 38-74 mi/hr
(3) Hurricane - cyclone with wind speed > 74 mi/hr
(4) Land docked hurricane
(a) loses moisture source
(b) frictional effect of land slows winds
(c) pressure gradient dissipated

C. Identification
1. weather satellit imagery
2. storm tracking and prediction
3. emergency management and contingency in coastal areas

D. Destructive Force
1. high winds/wind shear
2. Storm surge in coastal areas