PRESSURE AND WIND

I. PRESSURE MEASUREMENT

A. Air Pressure: important factor in controlling wind, wind speed, advective air movement, storm patterns

B. Air Pressure Relationships

1. Air Pressure = force exerted by the weight of the air above

2. Altitude Relationships

a. with > altitude, < air column, < Pressure

Altitude (km)	Altitude (mi)	Pressure (mb)
0	0	1013
1	0.6	899
2	1.2	795
3	1.9	701
4	2.5	617
5	3.1	540
10	6.2	265
20	12.4	55
30	18.6	12
40	24.8	3

C. Units of air pressure

1. at sea level

a. Pressure = 1 kg/sq. cm = 1013.2 millibars (mb) = 29.92 inches of mercury = 76 cm of mercury

D. Mercurial Barometer

1. Barometer

a. filled glass tube with liquid mercury

b. inverted in base dish with pool of mercury

c. mercury flowed out of tube until column of mercury was balanced by weight of the air column pushing on the pooled dish of mercury

(1) wt. of air column = wt. of mercury column in tube

2. Increasing Air Pressure: pushes mercury higher in tube

3. Decreasing Air Pressure: mercury falls in tube

II. FACTORS AFFECTING WIND

A. General

1. Wind = horizontal movement of air (advective motion)

2. Wind and Pressure

a. basic gas law: air of higher pressure moves towards air of lower pressure

b. wind = drive toward equilbrium of air pressure

3. Pressure Differences on Earth's Surface
   a. Caused by unequal heating of atmosphere by sun
   b. Variable solar insolation due to tilt of earth, orbital path, latitudinal changes

B. Factors Influencing Air Motion
1. General : if earth did not rotate and there were no friction of air motion, wind would be simply controlled by air motion from high pressure to low pressure

2. Influencing factors
   a. Pressure Gradient Force- degree of pressure changes per unit distance
   b. Coriolis Effect- motion on rotating objects/centrifugal force
   c. air friction- resistance to flow

C. Pressure Gradient Force

1. Pressure variation = wind
   a. > press. diff, > wind speed
2. Mapping air pressure
   a. pressure contour maps
   b. isobars = lines on constant air pressure

3. Pressure Gradient = $\frac{\text{change in pressure}}{\text{unit distance}}$
   a. gradient to hill
      (1) steeper the hill (pressure gradient)
         (a) > press. gradient, > wind acceleration
         (b) > close spacing of isobars

      (2) gentler the hill slope (pressure gradient)
         (a) < press. gradient, < wind acceleration
         (b) widely spaced isobars

4. Coriolis Effect
   a. Coriolis = apparent shift due to rotation
      (1) Earth rotating in counterclockwise direction as viewed from north pole
      (2) Net result:
         (a) Northern Hemisphere: air deflected to right in the direction of travel
         (b) Southern Hemisphere: air deflected to left in direction of travel

   b. View from north pole
      (1) counter clockwise rotation
      (2) air deflection to right, due to coriolis

   c. View from south pole
      (1) clockwise rotation
      (2) air deflection to left, due to coriolis

d. Coriolis relationships
(1) deflection always directed at right angles to direction of airflow
(2) deflection affects only wind direction, not wind speed
(3) deflection affected by wind speed
(a) > speed, > deflection

5. Friction
a. friction of air motion with earth's surface/topography
b. acts to slow wind velocity
(1) tends to deflect wind via "refraction"
(2) friction effects prominent to 2000 Ft altitude
c. rough mountainous landscape: > friction
d. smooth ocean surface: < friction

6. Air motion and Isobars

a. in frictionless, non-rotating environment, air motion perpendicular to isobars
b. Coriolis + friction effects ------
(1) Upper level (high altitude) airflow parallel to isobars
(a) Jet stream: "rivers of air" flowing at 75-150 mph at upper altitudes (reduced friction > speed)
(2) near-surface air flow winds cross isobars at an acute angle

III. CYCLONES AND ANTICYCLONES

A. General
1. Cyclones: low pressure center
2. Anticyclones: high pressure center

B. Cyclonic and Anticyclonic Winds
1. Cyclones
a. Northern Hemisphere
(1) low pressure center (influenced by coriolis and friction)
(2) winds blow inward and counterclockwise around the low
b. Southern Hemisphere
(1) winds blow inward and clockwise

2. anticyclones
a. Northern Hemisphere
(1) high pressure center
(2) winds blow outward and clockwise around the high
b. Southern Hemisphere
(1) winds blow outward and counterclockwise

C. Weather Generalizations about Highs and Lows
1. Rising air: associated with clouds/precipitations
2. subsiding air: adiabatic heating and clearing conditions
3. Cyclone: low pressure system

a. inward flow of air
b. winds converge to center
(1) air pile up
(2) pushes air upward
(3) > pressure due to rising column of coverged air (a paradox, low pressure results in > pressure)
(4) rising air cools adiabatically---- clouds/condensation---precipitation associated with low pressure system

4. Anticyclone: high pressure system
a. outward flow of air
b. winds diverge from center
(1) air descends and thins
(2) pushes air downward
(3) descending air is compressed and warmed
(4) air moisture vaporizes and clears

5. Short range weather predictions
a. barometric tendency
(1) rising barometeter: high pressure system approaching, clearing weather
(2) falling barometer: low pressure system approaching, clouds and rain
b. Cyclones---- rain
c. Anticyclones---- clear

IV. GENERAL CIRCULATION OF ATMOSPHERE
A. Causes of Air Motion
1. Unequal heating of earth's surface
a. Tropical Regions/Low Latitudes = receive > solar radiation, less reflection
b. Polar Areas = receive < solar radiation, > reflectance/albedo

2. General Circulation (ideal on a non-rotating earth)
a. Heat Imbalance: high at equator, low at poles
(1) warm air rises from equator and circulates symmetrically to north and south pole
(2) cold air sinking at the poles, circulated back to equator for reheating/circulation

b. Complications to the ideal model
(1) friction/turbulence
(2) coriolis: effects of air motion due to centrifugal force on a rotating planet
(3) secondary ocean current influences

** Result: breaks air flow into smaller cells of circulation, mid-latitude circulation shows complex airflow patterns

3. Idealized Global Circulation of Air on a Rotating Planet

a. Standard terminology for wind direction
   (1) Easterly wind: blowing from east to west
   (2) Westerly wind: blowing from west to east
   (3) Southwesterly: blowing from southwest to NE,... etc.

b. Equatorial Low
   (1) Low pressure Zone at Equator
   (2) Warming/Rising Air
   (3) Convergence of Northeasterly Trade Winds and Southeasterly Trade Winds
   (4) Abundant Precipitation/Tropical Climates

c. Subtropical High

   (1) Zone of subsiding, adiabitically warming air at 30 N and S latitudes
   (2) Warm/arid areas
      (a) World deserts in this belt
         i) Australian Desert
         ii) Arabian Peninsula
         iii) Sahara Desert
         iv) Gobi Desert

   (3) Divergent air at subtropical high, adiabatic warming, air diverging pushed to the south and north at 30 degree high
      (a) Trade Winds: reliable steady winds
         i) N. Hemisphere: northeasterlies pushed back to soutwest towards equator
            a) Deflected to right (SW) due to coriolis

         ii) S. Hemisphere: southeasterlies pushed back to the northwest towards equator
            a) Deflected to left (NW due to coriolis

      (b) Mid-latitude Westerlies: North and south of 30 degrees N. and S. latitude
         i) remainder of diverging, subsiding air (in Hadley cell) forced north and south respectively
         ii) Northern Hemisphere: air pushed to north, deflected to the right in an eastward direction--- forming westerlies

d. Subpolar Low

   (1) Northern portion of mid-latitude cell with air rising, < pressure to form subpolar low
   (2) Polar Easterlies
   (3) Polar Front
      (a) contact between cold polar air and warm mid-latitude air
      (b) Forms stormy northern belt

e. Polar High
(1) At poles: high pressure
(2) cold subsiding dry air forced equatorward

f. Summary
(1) Four Pressure Zones
(a) Subtropical and Polar highs
i) dry subsiding air pushed equatorward
(b) Equatorial and Subpolar Lows
i) converging and upward moving airflow
ii) sites of precipitation/instability

V. CIRCULATION IN MID-LATITUDES (Between 30 and 60 Latitude)

A. Complexities in the zone of the westerlies (mid-latitude)

1. Does not fit convective model well

2. west to east flow interrupted by migration of cyclones (low-press, counterclockwise systems) and anticyclones (high press, clockwise systems)
a. cyclones: precipitation
b. anticyclones: clear skies
3. Complicated upper airflow patterns

B. Seasonal Variations in upper air flow
1. Wind Speed
a. cool season: increased wind speed in upper air flow
2. Temperature Gradient
a. steeper in winter months
3. Fluctuation in position of polar jet stream
a. winter: cool arctic air pushed further south
(1) may be pushed as far as central Fla... freezing in Fla.
b. summer: more northward

C. Erratic behavior of upper level air, makes longer range predictions of weather uncertain at mid-latitudes

VI. LOCAL WINDS
A. Seas and Land Breezes
1. Variation in coastal winds daily due to water having higher heat capacity than land
a. i.e. land warms and cools faster than ocean on daily basis
b. Differential heating
2. Daytime: Sea breezes (towards land)
a. cool sea air directed inland
b. land and air above heats faster than ocean
c. land air---warm, rises, circulates out to sea
d. sea air relatively cool, descends and pushed towards land

3. Nightime: Land breezes (towards sea)

a. land and overlying air cools/loses heat faster than ocean
b. land air cools, subsides and forced in oceanward direction
c. ocean air warms and rises circulating landward

B. Valley and Mountain Breezes
1. Differential heating
a. Day: valley air warms rises up mountain slopes (valley breezes)
b. Night: upslope air cools and subsides down mountain slopes (mountain breezes)

C. Chinook and Santa Ana Winds
1. Chinooks: warm dry winds on eastern slopes of Rockies
a. adiabatic warming of air as it compresses and descends down leeward (east) side of Rockies
b. leeside warm, dry air
c. common in winter, spring, although inherently not that warm, warm enough to moderate freezing temps. and to melt snow
2. Santa Ana Winds
a. hot dry winds from east that flow into southern California
b. Descend down western slopes of Sierras
(1) >fire hazard