AVIATION WEATHER (chapter 5)

CAUSES OF WEATHER

1. Every physical process of weather is accompanied by, or is the result of, heat exchanges.

2. Unequal heating of the Earth's surface causes differences in pressure and altimeter settings.

3. The Coriolis force deflects winds to the right in the Northern Hemisphere. It is caused by the Earth's rotation.

    a. The deflections caused by Coriolis force are less at the surface due to the slower wind speed.
    b. The wind speed is slower at the surface due to friction between wind and the Earth's surface.

CONVECTIVE CURRENTS

1. Sea breezes are caused by cool and more dense air moving inland off the water. Once inland, over the warmer land, the air heats up and rises. Currents push the air over the, water where it cools and descends, starting the process over again.

2. The development of thermals depends upon solar heating.

FRONTS

1. A front is the zone of transition (boundary) between two air masses of different density e.g., the area separating a high-pressure system and a low-pressure system.

2. There is always a change in wind when flying across a front.

3. The most easily recognizable change when crossing a front is the change in temperature.

THUNDERSTORMS

1. Thunderstorms have three phases in their life cycle:

    a. Cumulus: The building stage of a thunderstorm when there are continuous updrafts.

    b. Mature: The time of greatest intensity when there are both updrafts and downdrafts (causing severe wind shear and turbulence).
        1) The commencing of rain on the Earth's surface indicates the beginning of the mature stage of a thunderstorm.

    c. Dissipating: When there are only downdrafts; i.e., the storm is raining itself out.

2. Thunderstorms are produced by cumulonimbus clouds. They form when there is

    a. Sufficient water vapor ,
    b. An unstable lapse rate, and
    c. An initial upward boost to start the process.

3. Thunderstorms produce wind shear turbulence, a hazardous and invisible phenomenon particularly for airplanes landing and taking off.

    a. Hazardous wind shear near the ground can also be present during periods of strong, temperature inversion.

4. The most severe thunderstorm conditions (heavy hail, destructive winds, tornadoes, etc.) are generally associated with squall line thunderstorms.

    a. A squall line is a nonfrontal narrow band of thunderstorms usually ahead of a cold front.

5. A thunderstorm, by definition, has lightning because that is what causes thunder.

6. Embedded thunderstorms are obscured (i.e., pilots cannot see them) because they occur in very cloudy conditions.

ICING

1. Structural icing requires two conditions:

    a. Flight through visible moisture, and
    b. The temperature at freezing or below.

2. Freezing rain usually causes the greatest accumulation of structural ice.

3. Ice pellets are caused when rain droplets freeze at a higher altitude, i.e., freezing rain exists above.

MOUNTAIN WAVE

1. Lenticular clouds are almond or lens-shaped clouds, usually found on the leeward side of a mountain range.

    a. They may contain winds of 50 kt. or more.
    b. They appear stationary as the wind blows through them.

2. Expect mountain wave turbulence when the air is stable and winds of 40 kt. or greater blow across a mountain or ridge.

WIND SHEAR

1. Wind shear can occur at any altitude and be horizontal and/or vertical, i.e., whenever adjacent air is flowing in different directions or speeds.

2. Expect wind shear in a temperature inversion whenever wind speed at 2,000 to 4,000 ft. AGL is 25 kt. or more.

3. Hazardous wind shear may be expected in areas of low-level temperature inversions, frontal zones, and clear air turbulence.

TEMPERATURE/DEW POINT AND FOG

1. When the air temperature is within 5° of the dew point and the spread is decreasing, you should expect fog and/or low clouds.

    a. Dew point is the temperature at which the air will have 100% humidity, i.e., be saturated.
    b. Thus, air temperature determines how much water vapor can be held by the air.
    c. Frost forms when both the collecting surface is below the dew point of the adjacent air AND the dew point is below freezing. Frost is the direct sublimation of water vapor to ice crystals.

2. Water vapor becomes visible as it condenses into clouds, fog, or dew.

3. Evaporation is the conversion of liquid to water vapor.

4. Sublimation is the conversion of solids (e.g., ice) to water vapor or water vapor to solids (e.g., frost).

5. Radiation fog (shallow fog) is most likely to occur when there is a clear sky, little or no wind, and a small temperature/dew point spread.

6. Advection fog forms as a result of moist air condensing as it moves over a cooler surface.

7. Up slope fog results from warm, moist air being cooled as it is forced up sloping terrain.

8. Precipitation-induced fog occurs when warm rain or drizzle falls through cool air and evaporation from the precipitation saturates the cool air and forms fog.

a. Precipitation-induced fog is usually associated with fronts.
b. Because of this, it is in the proximity of icing, turbulence, and thunderstorms.

9. Steam fog forms in winter when cold, dry air passes from land areas over comparatively warm ocean waters and is composed entirely of water droplets that often freeze quickly.

a. Low-level turbulence can occur and icing can become hazardous in steam fog.

CLOUDS

1. Clouds are divided into four families based on their height:

a. High clouds
b. Middle clouds c. Low clouds
d. Clouds with extensive vertical development

2. The greatest turbulence is in cumulonimbus clouds.

3. Towering cumulus are early stages of cumulonimbus; they usually indicate convective turbulence.

4. Lifting action, unstable air, and moisture are the ingredients for the formation of cumulonimbus clouds.

5. Nimbus means rain cloud.

6. When air rises in a convective current, it cools at the rate of 5.4°F/1,000 ft., and its dew point decreases 1°F/1,000 ft. The temperature and dew point then are converging at 4.4°F/1,000 ft.

a. Since clouds form when the temperature/dew point spread is 0°, we can use this to estimate the bases of cumulus clouds.

b. The surface temperature/dew point spread divided by 4.4°F equals the bases of cumulus clouds in thousands of feet above ground level (AGL).

c. EXAMPLE: A surface dew point of 56°F and a surface temperature of 69°F results in an estimate of cumulus cloud bases at 3,000 ft. AGL: 69°F -56°F = 13°F temperature/dew point spread; 13°F/4.4°F = approximately 3,000 ft. AGL.

STABILITY OF AIR MASSES

1. Stable air characteristics
a. Stratiform clouds
b. Smooth air
c. Fair-to-poor visibility in haze and smoke d. Continuous precipitation

2. Unstable air characteristics
a. Cumuliform clouds b. Turbulent air
c. Good visibility
d. Showery precipitation

3. When air is warmed from below, it rises and causes instability.

4. The lapse rate is the decrease in temperature with increase in altitude. As the lapse rate increases (i.e., air cools more with increases in altitude), air is more unstable. a. The lapse rate can be used to determine the stability of air masses.

5. Moist, stable air moving up a mountain slope produces stratus type clouds as it cools.

6. Turbulence and clouds with extensive vertical development result when unstable air rises.

7. Steady precipitation preceding a front is usually an indication of a warm front, which results from warm air being cooled from the bottom by colder air .

    a. This results in stable air with stratiform clouds and little or no turbulence.

TEMPERATURE INVERSIONS

1. Normally, temperature decreases as altitude increases. A temperature inversion occurs when temperature increases as altitude increases.

2. Temperature inversions usually result in a stable layer of air.

3. A temperature inversion often develops near the ground on clear, cool nights when the wind is light.

    a. It is caused by terrestrial radiation.

4. Smooth air with restricted visibility is usually found beneath a low level temperature inversion.