

## Unit 7 Aviation Weather

### 7.1 Causes of Weather

- Every physical process of weather is accompanied by or a result of heat exchanges
- Unequal heating of the Earth's surface causes differences in pressure
- Coriolis force deflects winds to the right in the Northern Hemisphere due to earth's rotation
  - Coriolis effect is less at the surface due to slower wind speed. Wind speed is slower due to friction at the surface.

### 7.2 Convective Currents

- Sea breezes - caused by cool and dense air moving inland off the water
  - Once inland over warmer land, the air heats up and rises
  - Currents push the air over the water where it cools and descends - a convection current
- Development of thermals depends on solar heating

### 7.3 Fronts

- Front - a zone of transition (boundary) between two air masses of different density; the area separating a high pressure and low pressure system
- There is always a change in wind when flying across a front
- The most easily recognizable change when crossing a front is the change in temperature.

### 7.4 Thunderstorms

- Three phases in the lifecycle of a thunderstorm
  - Cumulus - building stage of a thunderstorm when there are continuous updrafts.
  - Mature - time of greatest intensity; both updrafts and downdrafts causing severe turbulence and windshear
    - Start of rainfall on the sfc indicates beginning of the mature stage
    - Precip descends through the cloud and drags adjacent air downward, creating a strong downdraft. It spreads out across the surface, well in advance of the parent thunderstorm cell, as a mass of cool, gusty air.
  - Dissipating - when there are only downdrafts (the storm is raining itself out)
- Thunderstorms - cumulonimbus clouds. Form when there is sufficient water vapor, unstable lapse rate, and an initial upward boost to start the process.
- Produce wind shear turbulence, a hazardous and invisible phenomenon particularly for airplanes landing and taking off
  - Adverse winds are always found within thunderstorms and often many miles away from the precipitation area
    - Crosswinds, gusts, and variable winds/sudden shifts can lead to a crash during takeoff, approach, and landing
  - Hazardous wind shear near the ground can also be present during periods of strong temp inversion

- Do not attempt to fly under the anvil of a thunderstorm, because there is still potential for severe and extreme clear air turbulence
- Most severe thunderstorm conditions (heavy hail, destructive winds, tornadoes, etc.) are generally associated with squall line thunderstorms.
  - Squall line - a nonfrontal narrow band of thunderstorms, usually ahead of a cold front
  - Pilots should anticipate possible hail with any thunderstorm, especially beneath the anvil of a large cumulonimbus.
- Thunderstorms have lightning by definition
- Embedded thunderstorms are obscured (pilots can't see them) b/c they occur in very cloudy conditions.

#### 7.5 Icing

- Structural icing requires two conditions: flight through visible moisture and temp at freezing or below
- Freezing rain usually causes the greatest accumulation of structural ice
- Ice pellets are caused when rain droplets freeze at a higher altitude (freezing rain exists above)
- Frost - when the temp of the collecting surface is at or below the dewpoint of the adj air, and the dewpoint is below freezing
  - Water vapor changes its physical state through deposition and immediately forms as ice crystals on the wing surface
- Frost on wings disrupts smooth airflow over the airfoil by causing early airflow separation from the wing. Decreases lift, causes friction, and increases drag.
- Frost may make it difficult or impossible for an a/c to takeoff
- Frost should be removed before attempting to take off.

#### 7.6 Mountain Wave

- Lenticular clouds - almond or lens shaped clouds, usually found on the leeward side of a mountain range. May contain winds of 50 kts or more; appear stationary as the wind blows through them
- Expect mountain wave turbulence when the air is stable and winds of 40 kt or greater blow across a mountain or ridge

#### 7.7 Wind Shear Avoidance

- Can occur at any altitude and be horizontal and/or vertical; whenever adj air is flowing in different directions or speeds
- Expect wind shear in a temp inversion whenever wind speed at 2000-4000 AGL is 25 kts or more
- Hazardous wind shear may be expected in areas of low-level temp inversions, frontal zones, and clear air turbulence

#### 7.8 Temperature/Dew Point and Fog

- When air temp is within 5F of the dewpoint and the spread is decreasing, you should expect fog and/or low clouds.
  - Dew point - temp where the water has 100% humidity. Air temp determines how much water vapor can be held by the air.
- Water vapor becomes visible upon condensation as fog, clouds, or dew
- Evaporation - conversion of liquid to water vapor
- Sublimation - solid directly to gas; deposition - gas directly to solid
- Radiation fog (shallow fog) - most likely to occur when there is a clear sky, little to no wind, and small temp/dewpoint spread
- Advection fog - forms as a result of moist air condensing as it moves over a cooler surface
- Upslope fog - results from warm, moist air being cooled as it is forced up sloping terrain
- Precipitation-induced fog: when warm rain or drizzle falls through cool air and evaporation from the precipitation saturates the cool air and forms fog
  - Precip-induced fog is usually associated with fronts. Because of this, it is in the proximity of icing, turbulence, and thunderstorms.
- Steam fog - forms in winter when cold, dry air passes from land areas over comparatively warm ocean waters. It is composed entirely of water droplets that often freeze quickly.
  - Low-level turbulence can occur; icing can become hazardous in steam fog

## 7.9 Clouds

- Divided into 4 families based on their height
  - High clouds, middle clouds, low clouds, and clouds with extensive vertical development
- Greatest turbulence is in cumulonimbus clouds
- Towering cumulus are early stages of cumulonimbus; usually indicate convective turbulence
- Lifting action, unstable air, and moisture are the ingredients for the formation of cumulonimbus clouds.
- Nimbus means rain cloud
- When air rises in a convective current, it cools at the rate of 5.4F/1000 ft, and its dew point decreases 1F/1000 ft. the temp and dew point are therefore converge at 4.4F/1000 ft.
  - Since clouds form when the temp/dewpoint spread is 0, we can use this to estimate the bases of cumulus clouds
  - Surface temp/dewpoint spread divided by 4.4 equals the bases of cumulus clouds in thousands of feet AGL
    - Ex: surface temp/dewpoint of 69/56 means 3000 ft AGL cumulus cloud bases, since  $(69-56)/4.4 = 3$

## 7.10 Stability of Air Masses

- Stable air characteristics: stratiform clouds, smooth air, fair-to-poor visibility in haze and smoke, continuous precipitation, cool, and dry
- Unstable air characteristics: cumuliform clouds, turbulent air, good visibility, showery precip, warm, and humid
- When air is warmed from below, it rises and causes instability
- Lapse rate = decrease in temp with increase in altitude. As the lapse rate increases (air cools more with increases in altitude), air is more unstable.
  - Ambient lapse rate can be used to determine the stability of air masses
  - Cloud types and type of precip can also be used to determine stability of an air mass
- Moist, stable air moving up a mountain slope produces stratus clouds as it cools
- Turbulence and clouds with extensive vertical development result when unstable air rises
- Steady precip preceding a front is usually an indication of a warm front, which results from warm air being cooled from the bottom by colder air. Results in stable air with stratiform clouds and little or no turbulence

#### 7.11 Temperature Inversions

- Normally, temp decreases as altitude increases. Temp inversion occurs when temp increases as altitude increases
- Temp inversions usually result in a stable layer of air
- Temp inversion often develops near the ground on clear, cool nights when the wind is light
  - Caused by terrestrial radiation
  - Temp and radiation variations over land with a clear sky typically lead to the minimum temp occurring just after sunrise when the incoming solar radiation is not yet strong enough to offset the terrestrial radiation from the earth
- Smooth air with restricted visibility is usually found beneath a low-level temp inversion.

#### Unit 7 Quiz 62/68

#### Missed Questions 6

3. The wind at 5,000 AGL is southwesterly while it is southerly at the surface. The difference in direction is due to friction at the surface, since the coriolis force has more effect on faster moving winds. The winds are faster at altitude b/c there is less friction than there is at the surface.
38. Clouds, fog, or dew always form when water vapor condenses. Even if the RH is 100%, condensation may not necessarily form.
40. Advection fog forms when an air mass moves inland from the coast in winter.
49. If the surface altitude is 1,000 MSL (0 AGL), the calculation for cumulus cloud base must be adjusted accordingly ( $\text{temp-dew}/4.4 * 1000 \text{ AGL}$ ), + the initial MSL altitude.
50. Cumulus clouds often indicate turbulence. Temperature inversions prevent cumulus clouds from forming.
62. Stability of air can be determined through cloud types and types of precipitation

