lost its moisture and energy in the prefrontal thunderstorms. In the United States, tornadoes are frequently associated with strong prefrontal squall lines. Pre-frontal squall line thunderstorms are indicated on a surface weather map by an alternate dash-dot-dash line (display).

The distribution of stationary front thunderstorms is controlled by the slope of the frontal surface. Steeply sloped stationary fronts tend to have lines of storms, whereas shallow stationary fronts tend to have widely scattered storms.

Occluded front thunderstorms are associated with the two types of occluded fronts (warm front and cold front occlusions), and are usually cold front thunderstorms that have been moved into the area of warm frontal weather by the occlusion process. They are found along the upper front, and are normally strongest for a distance of 50 to 100 miles north of the peak of the warm sector.

Air Mass Thunderstorms

The two types of air mass thunderstorms are locally convective and orographic. Both types form within air masses, and are randomly distributed throughout the air mass.

Convective thunderstorms are often caused by solar heating of the land, which provides heat to the air, thereby resulting in thermal convection. Relatively cool air flowing over a warmer water surface may also produce sufficient convection to cause thunderstorms. The land-type convective thunderstorms normally form during the afternoon hours, after the Earth has gained maximum heating from the sun. If cool, moist, conditionally unstable air is passing over this land area, heating from below will cause convective currents, thereby resulting in towering cumulus or thunderstorm activity. Dissipation usually occurs during the early evening hours, as the land begins to lose its heat to the atmosphere. Although convective thunderstorms form as individual cells, they may become so numerous over a particular geographical area that continued flight cannot be maintained.

Thunderstorms over the ocean are most common during the night and early morning. They frequently occur offshore when a land breeze is blowing toward the water. The cool land breeze is heated by the warmer water surface, which results in sufficient convection to produce thunderstorms. After sunrise, heating of the land surface reverses the airflow (sea breeze). The thunderstorms then dissipate over the water, but they may re-form over the warmer land surface. As an example, the air mass weather that exists in Florida combines both types of convective thunderstorms. Circulation around a semipermanent high pressure system off the southeastern United States (Bermuda high) carries moist ocean air over the warm land surface of the Florida Peninsula. At night, thunderstorms off the Florida Coast are caused by the warm water of the Gulf Stream heating the surface air, while the upper air is cooling by radiation to space. This heating from below produces thermal convection over the water. When the sun rises, the heat balance necessary to maintain storm formation over the water is destroyed. By day, the storms appear to move inward over the land areas, but actually dissipate off the coast and re-form over the hot landmass. The heated land surface sets up an unstable lapse rate over the Peninsula and causes storm development to continue until nocturnal cooling occurs. Usually, convective type storms are randomly distributed and easily recognized.

Orographic thunderstorms will form on the windward side of a mountain if conditionally unstable air is lifted above the level of free convection. The storm activity is usually scattered along the individual peaks of the mountains. Occasionally, however, this activity may form a long unbroken line of storms similar to a squall line. The storms persist as long as the circulation causes upslope motion. From the windward side of the mountains, identification of orographic storms may sometimes be difficult because the storm clouds are obscured by other clouds (usually stratiform). Almost without exception, orographic thunderstorms enshroud mountain peaks or hills.

Minimum Factors

The minimum factors essential to the formation of a thunderstorm are conditionally unstable air with relatively high moisture content and some type of lifting action. Lifting of warm air will not necessarily cause free convection. The air may be lifted to a point where the moisture condenses and clouds form. These cloud layers, however, will be stable if the level of free convection has not been reached by the lifting. Conversely, it is possible for dry heated air to rise convectively without the formation of clouds. In this condition, turbulence might be experienced in perfectly clear weather. Cumulonimbus cloud formations require a combination of conditionally unstable air, some type of lifting actions, and high moisture content. Once a cloud has formed, the latent heat of condensation released by the change of state from vapor to liquid tends to make the air more unstable.

Some type of external lifting action is necessary to bring the warm surface air to the point where it will continue to rise freely (the level of free convection). For example, an air mass may be lifted by thermal convection, terrain, fronts, or convergence.

Summary

By no means is the information contained here a complete discussion of all the weather information and factors affecting balloon flight. There are many resources available, both