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# WEATHER SPRINGTIME INSTABILITY

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By Jack Williams

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## Rising air creates conditions to watch

Unless you do most of your flying in the southern parts of the country or out West, you're likely to celebrate the arrival of spring.

After the spring equinox, which occurs this year on Sunday, March 20, at 0431 Zulu time, the growing amount of sunlight will be warming the air, making all outdoor activities—including flying—more pleasant.

Nevertheless, you can't forget the weather. In fact, you need to turn your attention to the dangers of thunderstorms, which occur most often in spring and early summer because the atmosphere is more likely to be unstable.

**All about lapse rates.** To get a handle on how air acts as it rises, you need to untangle the different ways that meteorologists use the term lapse rate. In general, lapse rate refers to changes in temperatures with altitude. Learning about the two kinds of temperature lapse rates can help you understand stability.

The environmental lapse rate refers to the changes in temperatures with altitude of air that's not moving up or down. Meteorologists get this information from weather balloons and automatic reports from some airliners. You will often hear measurements of the environmental lapse rate called a "sounding."

The adiabatic lapse rate is the decrease in temperature of air that's rising or the increase in temperature of air that's sinking.

A bubble of rising air grows cooler because it is expanding as the pressure of the surrounding air decreases. The air's expansion uses energy taken from the rising air. A bubble of sinking air warms as the increasing pressure of the surrounding air compresses the bubble. Energy added to the sinking air by increasing air pressure warms the air.

**The 1, 2, 3 of atmospheric stability.** Here's how atmospheric stability affects rising air:

1. Rising air cools at a constant rate, which the temperature of the surrounding air does not affect.
2. Air rises as long as it is warmer—thus lighter—than the surrounding air.
3. An unstable atmosphere is one in which rising air will remain warmer than the surrounding atmosphere as it rises.

In contrast, when the atmosphere is stable, air will stop rising when it cools to a temperature that's equal to or colder than the surrounding air.

**What happens when air rises.** When air rises, it cools at the rate of 5.5 degrees Fahrenheit per each 1,000 feet as long as water vapor in the air is not condensing into drops of water. This is called the dry adiabatic lapse rate. Sinking air warms at the same rate, as long as water drops or ice crystals in the air are not melting or evaporating.

A bubble of air will rise as long as it's warmer than the surrounding air. Rising air is one of the most important weather makers, because air cools as it rises. If the air grows cold enough, its water vapor will begin condensing to form clouds and, eventually, rain or snow. In other words, for clouds and precipitation to form, air has to rise and cool.

Air can rise to form clouds and precipitation in both a stable and an unstable atmosphere. The different ways air rises in the two kinds of atmospheres determine what kinds of clouds and

precipitation form.

When the atmosphere is unstable, air that is given a shove upward will continue rising. Air pushed up over a mountain or an advancing warm front continues rising after the shove goes away, because it remains warmer than the surrounding air. When the rising air cools to the temperature of the surrounding air, it stops rising; the atmosphere at this altitude is no longer unstable.

When the atmosphere is unstable to high altitudes, vigorous thunderstorms can form if the air is humid enough. Whether vigorous thunderstorms or smaller clouds—maybe with showery rain but no lightning or thunder—form on an unstable day, the rising air currents and air descending nearby will create turbulence.

The initial shove that starts unstable air moving upward can be heating of the ground that makes bubbles of air warmer than surrounding air; converging winds; or a cold front, which acts like a plow that pushes warm air up.

Stable air rises only as long as something is shoving it up. A stable atmosphere does not guarantee clear skies, however. Wind blowing uphill can push stable air up to form fog or clouds. Widespread clouds and precipitation also form in stable air when a warm front pushes the air up, as warm air replaces cool air.

Conditionally unstable air occurs when the lapse rate of a column of air is less than the dry adiabatic lapse rate but greater than the moist adiabatic lapse rate. Rising air will be stable if unsaturated and unstable if saturated.

**How humidity makes the atmosphere more unstable.** When the water vapor in rising air begins condensing into water droplets, it releases latent heat. When condensation occurs in rising air, the added latent heat offsets to some degree the dry adiabatic lapse rate, creating a moist adiabatic lapse rate of approximately 3.3 degrees Fahrenheit per 1,000 feet.

Very humid air will rise faster and higher than dry air. This is why cumulus clouds are more likely to grow into thunderstorms when the air near the surface is very humid.

**How stability affects weather.** In general, if you fly when the atmosphere is unstable, expect turbulence. Unless the air is very dry, you'll see clouds that extend vertically (cumulus clouds). Any rain or snow will come and go as showers, with dry air—and possibly clear sky—in between.

Sometimes the atmosphere will be unstable only at lower altitudes. On such days clouds won't extend very high and the air above the clouds will not be as turbulent as the air between the clouds and the ground.

On the other hand, when the atmosphere is unstable to high altitudes, vigorous thunderstorms can form as long as the air isn't too dry. On the plus side, unstable weather usually clears out haze or smog by mixing air up and down and diluting pollution.

## **Jack Williams**

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