WEATHER TO FLY

BY DAN GUDGEL

Gradients

Within the Federal Aviation Administration (FAA) Practical ***Test Standards*** (PTS) for the Glider Category practical examinations there is an *"Area of Operations, Preflight Preparation"* section. The gathering of weather information is a specific task with the PTS and within that task, "*knowledge of pressure and temperature lapse rates in their relationship to the lifting process*" and "*atmospheric instability*" is to be understood by the applicant. In order to better understand components of lifting processes, I am going to focus this month's installment of "Weather to Fly" in a brief discussion of definitions and concepts in regard to atmospheric pressure and temperature lapse rates.

As a footnote in last month's discussion on *Ridge Lift*, temperature lapse rates were introduced. A lapse condition is one where the variable is diminishing or decreasing. Referencing Byers' textbook, *General Meteorology* (1), lapse rate is "*the rate of temperature decrease with height in the atmosphere overlying a point on the surface of the earth at any given time.*" In other words, typical conditions in the atmosphere tend to have the temperature decreasing as altitude is increased.

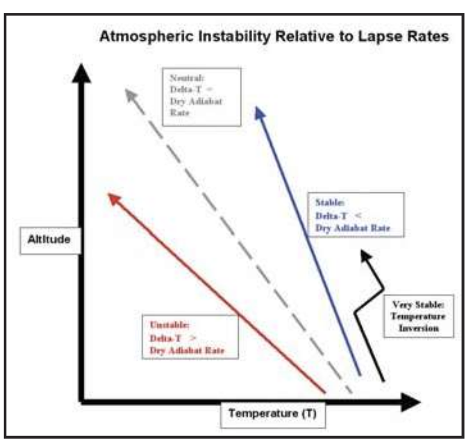


Diagram 1

In addition, if a lapse condition with the temperature decreasing with a gain in altitude is typical, then anytime the temperature increases with altitude then conditions are not typical or "inverted" from that normally expected. Hence, the deviation from a lapse temperature condition provides the background for the term "*inversion*" in defining the condition of warm air overlying cooler air. *[See **Diagram #1: Atmospheric Instability Relative to Lapse Rates**.]*

Through the various FAA aeronautical training manuals, especially in regard to general airframe and engine performance, the "*average*" lapse rate of 3.5 degrees Fahrenheit (F) decrease in temperature per 1000 feet of altitude gained is historically applied. However, I underscore that this particular lapse rate is nothing more than an *average* decrease in the temperature in the International Civil Aviation Organization's *Standard Atmosphere* through the Troposphere (the lowest 5 to 8 miles of the atmosphere). The average temperature lapse rate is NOT representative of any particular physical process in the atmosphere.

In review, the "*Dry Adiabatic Lapse Rate*" (DALR) is a constant as it defines a physical process in the atmosphere. From the *Glossary of Meteorology* (2) it is defined as "the rate of decrease of temperature with height of a parcel of dry air lifted in an adiabatic process through an atmosphere in hydrostatic equilibrium." The decrease in temperature with altitude of this atmospheric constant is 3 degrees Celsius(C) or 5.4 deg.F. per thousand feet; or the lapse rate in straight metric system terms is 9.8 deg.C. loss of temperature per kilometer of altitude. Adiabatic changes in temperature occur due to changes in the pressure of a gas (the atmosphere) as the parcel of air moves vertically up or down while not adding or subtracting any external thermal energy to that parcel.

The DALR constitutes a neutral atmosphere in regard to stability as we discuss the potential of the atmosphere to want to move vertically. A lapse rate that is greater than the DALR, i.e., a greater temperature decrease with altitude than 5.4 degs.F., is considered *unstable* and the atmosphere is ready to be "triggered" to turnover or result in upward vertical motion. Conversely, lapse rates that are not as steep or have a temperature decrease not as great as the DALR tend toward being more stable…with extreme stability being when the temperature increases with an increase in altitude in inversion conditions. Summarizing, an atmosphere that has temperature decreasing with altitude greater than the rate of the DALR of 5.4 degs.F. per thousand feet is considered unstable; and an atmosphere that does not have its temperature decrease at the DALR of 5.4 degs.F. per thousand feet trends toward a stable atmosphere.

Stability as defined previously by relationship to the DALR does change with considerations for the change of state of water vapor within a parcel of air. At this time and with expectations to define it better in a subsequent article, I simply state that stability of the atmosphere is heavily influenced by the changes in state of the water vapor. With the release of energy from water vapor upon reaching a point where water vapor condenses back to liquid water, the release of the latent heat that it took to vaporize that water from its liquid state actually warms a parcel of air.

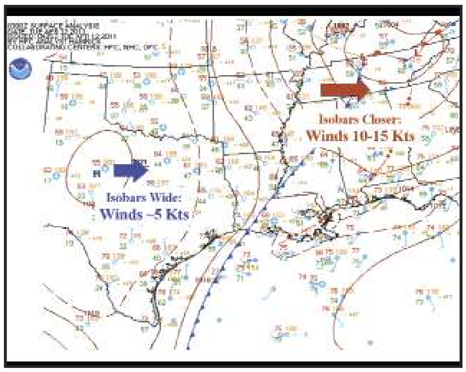
In either the case for the DALR or a lapse rate influenced by the latent heat of vaporization, the atmosphere's ability to be primed to contribute (or takeaway) to vertical motion that results in lifting processes for soaring are necessary ingredients. Once the atmosphere has become unstable (again as defined by the DALR), only some form of disturbance and/or initial lifting process is needed to encourage the atmosphere to provide a deep layer of vertical motion that is useful for soaring.

In aviation meteorology, another term that is frequently used is "*gradient.*" From the *Glossary of Meteorology*, gradient is defined as, *"the space rate-of-decrease of a function."* Gradient is a term that is applied frequently in descriptions concerning the force that produces wind and another instance in regard to the change in the wind vector through a layer of air, i.e., wind gradient.

In the first instance of the gradient term, aviation uses the word in reference to the differences in pressure from one point to another, or as *defined "the rate of decrease (gradient) of pressure in space at a fixed time."* Most frequently in aviation, we are referring to the magnitude of the pressure gradient or the pressure difference across a certain distance. Despite frictional influences that result in changes in the wind direction, air movement over the earth (wind) is the direct result of atmospheric pressure (*) differences.

(*) Atmospheric Pressure is defined in the *Glossary of Meteorology* as, *'the pressure exerted by the atmosphere as a consequence of gravitational attraction exerted upon the 'column' of air lying directly above the point in question."* In other words, the air in a column over a given point has a certain mass. In addition, that mass is under the influence of the earth's gravity like every other object. The barometer is an instrument that is used to assign a value to the atmospheric pressure at the point of measurement.

This pressure gradient results in a force that moves air from areas of *higher* pressure to *lower* pressure. Note that I did not say "*high pressure*" or "*low pressure*." The gradient force that moves air only needs the pressure difference to be relatively higher at some point thereby providing force that moves air toward a point with a lower pressure. The presence of a pressure gradient results in horizontal air movement, or wind. Intuitively, the larger the pressure gradient and resulting force on the air over a point on the earth then the result is a higher wind speed over that point. Conversely, a weak pressure gradient over a given point leads to a smaller wind speed. Wind speeds on a *Surface Weather Chart* are really reflecting the influence of the patterns of high and low pressure and the resulting pressure gradients over that chart. The spacing of the lines of equal pressure, isobars, on the Surface Weather Chart provides a measurement of the pressure gradient with each isobar four millibars, by convention, different from the adjacent isobar. The closer the isobars are together then the higher the wind speeds at the observation points near the tighter isobars. *[See: **Surface Weather Chart, Southeast U.S., at 03Z, April 12, 2011**.]*



Obviously, in its effect on the lifting processes, wind speed is an essential ingredient for the development of ***Ridge Lift***, ***Mountain Wave Lift***, and ***Shear/Convergence Lift***. However, pressure gradient force also influences the growth or detracts from ***Thermal Lift*** development. Discussions in regard to wind speed for development of ***Mountain Wave Lift*** and ***Shear/Convergence Lift*** will be addressed in future installments of *"Weather-to-Fly."*

Since the term *gradient* has been introduced in relationship to wind speed, allow me to discuss a vertical aspect of wind speed change we know as "*wind gradient.*" *Wind Gradient* is defined as a change in wind speed through the layer of air immediately over the surface. In the true definition of a gradient, wind gradient refers to the loss of wind speed as an aircraft descends toward the ground. Wind gradient is the largest and most noticeable in windy conditions and influences the landing phase of flight. It is surface or ground roughness (friction) that is the cause of the decrease in wind speed while descending in the lowest 100 to 150 feet of altitude above the landing surface. Because air does not "blow through" the ground, the wind speed immediately at the ground is zero. When a glider begins to get close to the surface and flying into the wind, the wind gradient has the effect of reducing the airspeed of a glider. Being of much more mass than the air, the glider's momentum changes only slowly yet the aircraft relatively and quickly transitions through the layer of decreasing wind speed. Without some compensation in the form of higher approach airspeeds, this loss of headwind component could result in sufficient loss of airspeed to stall the aircraft before reaching the point-of-flare. *[See **Diagram #2: Wind Gradient**.]* Exacerbating the effect of wind gradient can be turbulent eddies in the general wind flow caused by adjacent low-lying vegetation, trees, or even man-made structures such as hangars.

Much of the mystique of meteorology can be attributed to the vernacular of the trade. Hopefully a little insight into the meteorological term of "*gradient*" will enable aspiring soaring pilots to better understand weather charts and the processes that use the term for a description of the atmosphere's behavior.

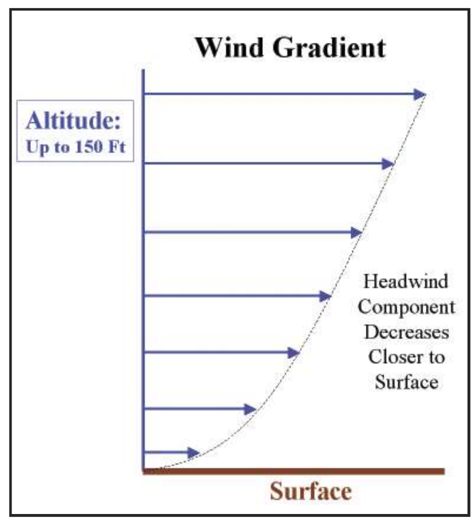


Diagram 2

References:

"*General Meteorology*", Horace Robert Byers, McGraw-Hill Book Company, Third Edition, c.1959

"*Glossary of Meteorology*", American Meteorological Society, Edited by Ralph E. Huschke, c.1959.

Library Build:

"*Daily Weather Maps*"; U.S. National Weather Service Hydrologic Prediction Center; URL: www.hpc.ncep.noaa.gov/dailywxmap/