WEATHER TO FLY

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Wind, Convergence, *and* Shear

This "*Weather-To-Fly*" series began with a listing of the types of lift commonly used for soaring flight. Over the last year, the series has presented information in regard to *Ridge*, *Thermal*, and *Mountain Wave* lift types. The remaining type to be considered for soaring flight is that of Convergence. Unlike the lift types discussed before, convergence lift develops in several ways. These different forms of convergence lift will be covered over the next few installments of *Weather-To-Fly*. This month we review some basic meteorology, and focus on providing some background for future convergence lift discussions.

As previously discussed, air (which has mass) moves in an attempt to reach equilibrium in relation to its mass distribution in the atmosphere. The *Equation of State for Dry Air* describes the relationship of mass, pressure, and density (See ***Text Box #1: "Equation of State for Dry Air"***). Density is expressed in terms of mass per unit of volume. If temperature remains constant, then pressure is directly a function of the density or the amount of mass in a given volume. Previous articles have illustrated that vertically-oriented density differences in the atmosphere result in vertical motion of the air. Likewise, density and pressure differences in a horizontal plane result in the movement of air that we know as the wind. Again, by physical laws, the atmosphere wants to reach equilibrium in terms of its mass concentration. Thus air movement is from an area of higher pressure (or higher density) to that of lower pressure (or lower density). The pressure gradient, or the rate of decrease of pressure over a horizontal plane such as the earth's surface, is the magnitude of the decreasing change of the pressure field at a specific time ***(Reference: AMS)***. This difference in pressure over the sur-

Equation of State for Dry Air

Defining Variables:

P	=	Pressure (in millibars or grams/centimeter^2 or mass/area)
ρ	=	Density (in grams/ centimeter^3 or mass/volume)
R	=	Specific Gas Constant
T	=	Absolute Temperature (in degrees Kelvin)

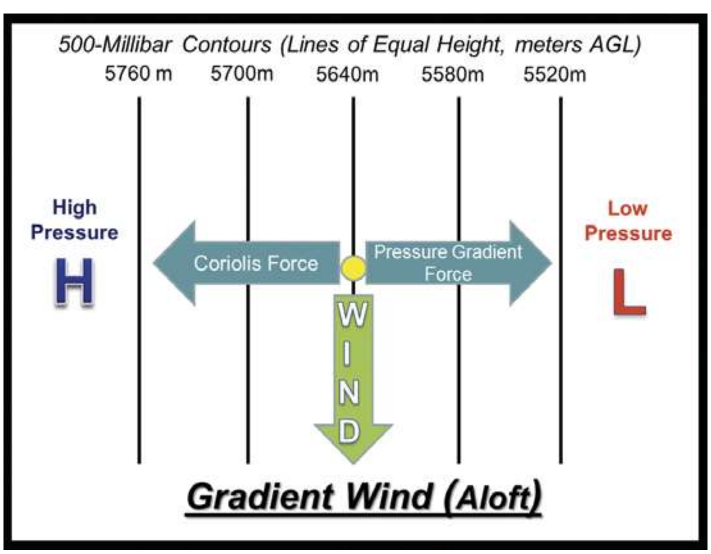
EQUATION OF STATE FOR DRY AIR:

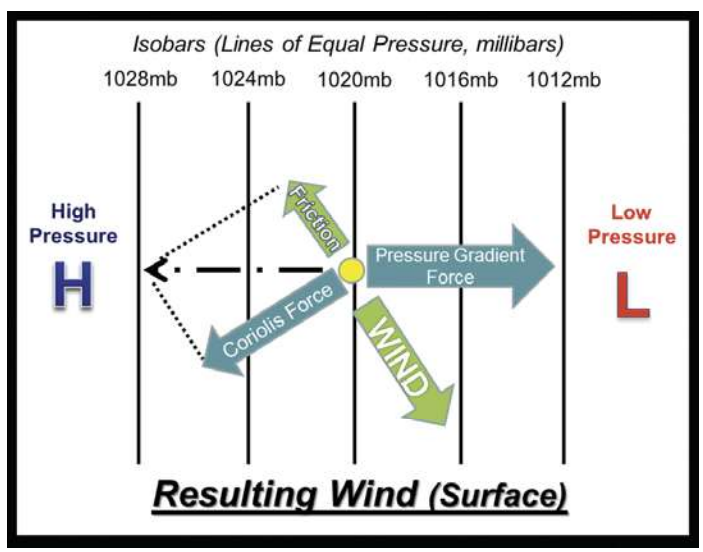
$$P = \rho R T$$

In referencing the equation, note the relationships of the variables:

Pressure, **P**, is proportional to Density, ρ, and/or Absolute Temperature, **T**.
Or,
Density, ρ, is directly proportional to the Pressure, **P**;
Or,
Density, ρ, is inversely proportional to the Temperature, **T**.

As defined by the equation, a pressure increase results in a density increase, and conversely a pressure decrease leads to a density decrease. A temperature increase will result in an air density decrease, and conversely a decrease in temperature will increase the air density (more mass).





face of the earth results in a force that moves air (mass) from one point to another. Air moves directly from higher pressure to lower pressure. However, an apparent force turns the air to the right in the Northern Hemisphere as seen from an observer's point-of-reference on the rotating earth. This apparent force is called the *Coriolis Force* ***(Reference: AMS)***. The stronger the *Pressure Gradient Force* and the resulting wind, then the stronger the *Coriolis Force*. At altitudes high enough to have minimal frictional influence from the earth's surface on air movement, the resulting wind is called a *Gradient Wind*. The wind direction of this Gradient Wind at altitude generally is tangent to the contour lines of an upper air constant-pressure chart (See ***Diagram #1: "Gradient Wind"***). Close to the earth's surface, frictional effects influence the balance between the Pressure Gradient Force and the Coriolis Force. *Frictional Force* slows the wind speed even though the Pressure Gradient Force remains. With decreased wind speed, the Coriolis Force is not as great and the wind direction does not turn as much to the right (Northern Hemisphere). The resulting wind moves across the lines of equal pressure (cross-isobaric wind flow) from higher pressure toward lower pressure (***See Diagram #2: Resulting Wind***). This is why wind directions reflect air moving at an angle away from High Pressure areas on a surface weather chart and subsequently flow at an angle toward Low Pressure (See ***Diagram #3: "Surface Pressure Gradient and the Wind"***).

Convergence, by definition, is the process or act of converging or coming together. In mathematics, convergence is defined as "the contraction of a vector field" (***Reference: AMS***). A vector has both a direction as well as a speed component, and in the atmosphere air movement has opportunity for 3-dimensional flow. When convergence of air flow occurs near the surface of the earth (and due to the law of conservation of mass), air is forced vertically upward since the earth below does not allow air movement downward. Thus, the horizontal movement of air with any component of convergence will result in upward air motion (See ***Diagram #4: "Speed and Direction Convergence"***). Aviation textbooks remind us that air "sinks" as it comes off the higher mass concentration of High Pressure and moves toward the lower mass concentration of Low Pressure (See ***Diagram #5: "Convergence at Surface Low Pressure"***).

As a point of clarification, glider pilots very often use the terms "*Shear*" and "*Convergence*" interchangeably. Convergent flow, such as air moving into areas of surface Low Pressure, will result in some form of upward, vertical motion (typically not strong enough to support soaring flight). "*Shear*" is a sharp, directional difference in air flow that may, or may not, have any convergence associated with it (See ***Diagram***

#6: "Shear Lines"). Shear will not necessarily result in upward vertical motion. So-called shear lines that support soaring flight, by definition, have a component of convergent flow that results in upward air motion. Convergent flow can occur in one of, or a combination of, two ways: wind speed changes, speed convergence, and/or wind direction (See ***Diagram #4: "Speed and Direction Convergence"***).

Again, the atmosphere behaves like a fluid. The mindset of any soaring pilot should always be envisioning the air around him or her as a fluid. With a vision of forces and mechanisms including convergence possibly at work in the fluid of air, and the use of conceptual models, the glider pilot is better able to use the atmosphere to soar. Having provided the basis for wind movement in this rendition, succeeding articles of "*Weather To Fly*" will focus on several situations that develop Convergent Lift.

References:

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[2] Huschke, Ralph E., Editor. "***Glossary of Meteorology***". American Meteorological Society (AMS), Boston, 1970.

[3] Baker, Michael. DOC/NOAA/National Weather Service. ***S-290 Fire Weather Course***, Boulder, CO, 2002.