WEATHER TO FLY

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Energy Diagrams

In the continuing discussion of determining if soaring flight is possible from thermal development, I have begun throwing around meteorology terms, definitions, and concepts with some abandonment of constraint. With so many references to "energy diagrams" in defining the atmosphere's stability, I would like to pause with this month's article to simply define and explain a few of the lines that are seen on those constantly referenced energy diagrams. Despite the appearance of complexity, the diagrams actually present a picture that visually simplifies physical processes that affect vertical air motion and, thus, describe the state of atmospheric stability.

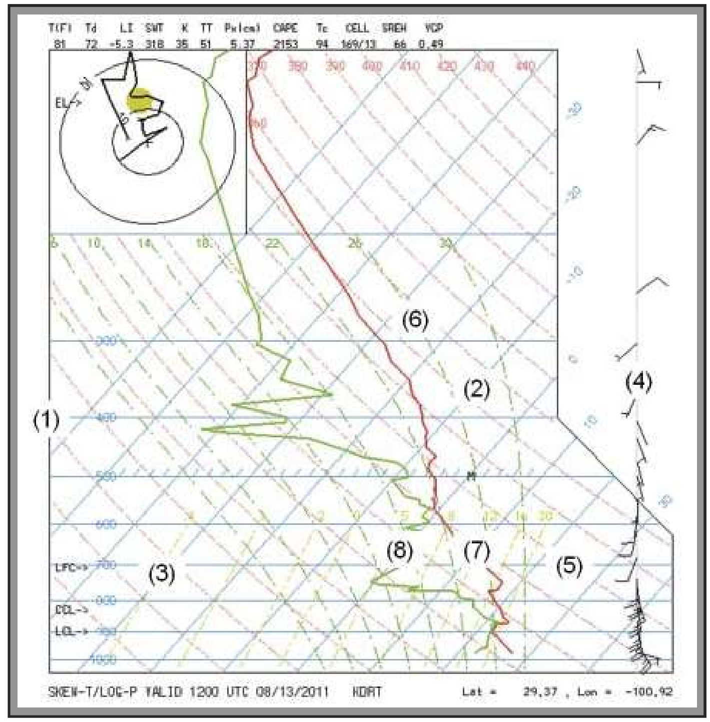
There are several different types of energy diagrams such as "Skew-T/Log-P," "Pseudo-Adiabatic," "Tephigram", "Emagram," etc. I am going to focus my explanation on energy diagrams using the Skew-T/Log-P Diagram, as the other energy diagrams are similar in function but vary in the way meteorological parameters are oriented on the diagrams. From the recently concluded Pre-World Soaring Championships and the U.S. Open Class Nationals, the atmosphere's temperature and stability was often depicted by use of radiosonde observations (Raob) over Del Rio, Texas

(DRT). A specific example of a Skew-T Log-P Diagram over DRT depicting atmospheric parameters on August 13, 2011, at 1200 hours Coordinated Universal Time (UTC or Z) is shown.

At 92 stations around North America and the Pacific, fast-rising, helium balloons with attached instrument packages are sent aloft twice per day at 0000Z and 1200Z. As the balloons rise with their instrument packages, temperature, humidity, and pressure are measured and, by tracking the balloon, wind direction and speed are derived. Keep in mind that the sounding data is a weather observation of the upper air. The gathered weather data is plotted and represented on constant pressure weather charts over the launch point. The obtained sounding does not give a true vertical dimension since the wind blows the balloon downstream. The gathered information is assumed to be over the launch point. Neither does the sounding give a true instantaneous measurement since it takes several minutes to travel from the surface to the upper troposphere. As a technical point, a radiosonde observation provides only pressure, temperature, and relative humidity data. When a radiosonde is tracked so that winds aloft are provided in addition to pressure, temperature, and relative humidity data, it has become a 'rawinsonde' observation. Most upper air launch stations around the world take rawinsonde observations. Meteorologists and other data users, including myself, frequently refer to a rawinsonde observation as a radiosonde observation.

In looking at the example of an upper-air Skew-T Log-P diagram commonly distributed on the internet web by the University of Wyoming through a link from the University Center for Atmospheric Research (UCAR), let's define some of the lines seen.

Isobars – Solid, bold lines of equal pressure in a shade of blue (Label: 1). They run horizontally from left to right and are labeled on the left side of the diagram. The vertical coordinate on the energy diagram is that of pressure expressed in millibars (mb). Pressure is given in increments of 100mb and ranges from 1050 to 100 mb. Notice the spacing between isobars increases in the vertical (thus the name Log P). Since pressure as measured at a given point on the surface of the Earth is the result of the mass of air above that point, the greater altitude one goes in the atmosphere then the pressure at that altitude will reflect a decrease as a result of a loss of mass above that point/altitude.



Isotherms – Lines of equal temperature. These solid, blue lines run from the lower left of the diagram toward the upper right across the diagram (thus the name, Skew-T). Increments are given for every 10 degrees in units of Celsius, i.e., 10 degrees, 20 degrees, etc. (Label: 2). The isotherm lines are labeled at the bottom of the diagram.

Saturation mixing ratio lines – Saturation mixing ratio is the dimensionless ratio of the mass of water vapor to the mass of dry air. On the energy diagram, it is expressed in a value of grams-per-kilogram. These light green-brownish, dashed lines run from just left of vertical upward to just right of vertical (Label: 3). The mixing ratio line values are labeled on the bottom of the diagram.

Wind barbs – Wind speed and direction given for each plotted barb. The wind information is plotted on the right of the diagram (Label: 4). The wind staff indicates the direction relative to True North *from* which the wind is blowing. Barbs on the wind arrow depict the wind speed and consistent with other weather products, i.e., one-half of a wind speed barb is equal to 5 knots, each full barb is 10 knots, and each solid triangular pennant represents 50 knots of wind speed.

Dry Adiabatic Lapse Rate (DALR) – The DALR is a rate of cooling (9.8 degrees Celsius per kilometer) due to an adiabatic expansion of a rising, unsaturated parcel of air. These slightly curved, light red, dashed lines on the Skew-T Log-P diagram arc to the right from the lower right upward with increasing height. Weather articles often reference the DALR as it pertains to thermals (Label: 5).

Moist Adiabatic Lapse Rate (MALR) – The MALR is a rate of cooling that depends on the moisture content of the air of a rising, saturated parcel of air. Owing to the release of latent heat, the MALR is less than the DALR. However, the MALR does increase with an increase in height since cold air has less moisture content than warm air. With the higher altitude and less water content available in that colder air, the MALR begins to approach that of the DALR. The MALR is indicated by dashed, light green lines that start to run vertical from the lowest portion of the chart but then curve to the left with increasing altitude (Label: 6).

Environmental sounding – This bold, red line represents the actual measured temperatures in the atmosphere (Label: 7). The temperature sounding is the jagged line running from bottom to top on the diagram. The sounding line is always to the right of the dew point line.

Dew point plot – This bold, green, jagged line runs from the bottom to the top of the diagram and it is the vertical plot of dew point temperature (Label: 8). The dew point line is always to the left of the environmental temperature sounding. The dew point is the temperature to which a given parcel of air must be cooled at constant pressure and constant water-vapor content in order for saturation (condensation) to occur.

With these lines on the diagram identified, I will discuss and elaborate on some of the atmospheric indices, interactions, and relationships that can be derived or described by reference to the various lines on the Skew-T Log-P Diagram in forthcoming articles.

References:

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