WEATHER TO FLY

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The Lifted Index Analysis Chart

The state of the atmosphere's stability is an important meteorological parameter to be considered by pilots contemplating possibilities for soaring flight. Historically, among the suite of National Weather Service (NWS) pilot weather briefing products was the *Lifted Index Analysis* Chart [See ***Chart #1: Lifted Index Analysis Chart***]. This chart presented the Lifted Index (LI) and the K-Index calculated from the upper air balloon soundings over the U.S. taken at the 0000 UTC (Universal Time Coordinated) and 1200 UTC hours. This so-called "Instability Chart" had its origins in the era prior to that of computer supported meteorological modeling. The indices as presented in this analysis were computed from observed weather parameters. I make this distinction because in this era of meteorology numerical models derive and generate such high-quality graphical weather products that the line between *forecast* and *observed* weather products can be easily blurred.

Referencing the sample *Lifted Index Analysis* Chart, note that it has its origin as the Department of Commerce's National Oceanographic and Atmospheric Administration (NOAA) National Center for Environmental Prediction (NCEP). This chart has been produced at the NWS Numerical Meteorological Center in Washington D.C. and subsequently distributed through the NWS Telecommunications Gateway to NWS Offices and Federal Aviation Administration (FAA) Flight Service Stations. The *Lifted Index Analysis* Chart presentation remained reminiscent of the facsimile machine era of weather products. On the chart, the computed meteorological indices were positioned over the balloon sounding sites and presented onto a Lambert-conformal conic projection of the United States. The indices were presented much like the form of a fraction. The Lifted Index was placed like that of a numerator in a fraction with the K-Index printed below in the place of a denominator. Lifted Index isopleth values of every four were lined on the chart (0, -4, etc.). The date and time of the soundings providing the indices was plainly presented.

Table #1

LIFTED INDEX	
Positive number	Stable
0 to -4	Marginal instability
-4 to -7	Large instability
-8 or less	Extreme instability

Table #1: Lifted Index Values and Atmospheric Instability
(Table Courtesy of Meteorologist Jeff Haby)

Chart #1

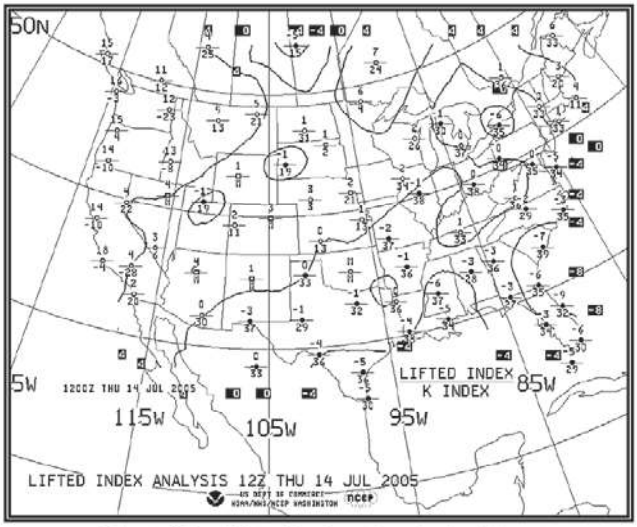


Chart #1: Lifted Index Analysis Chart
(Figure 5-38. *Aviation Weather Services, FAA Advisory Circular 00-45F*)

Chart #2

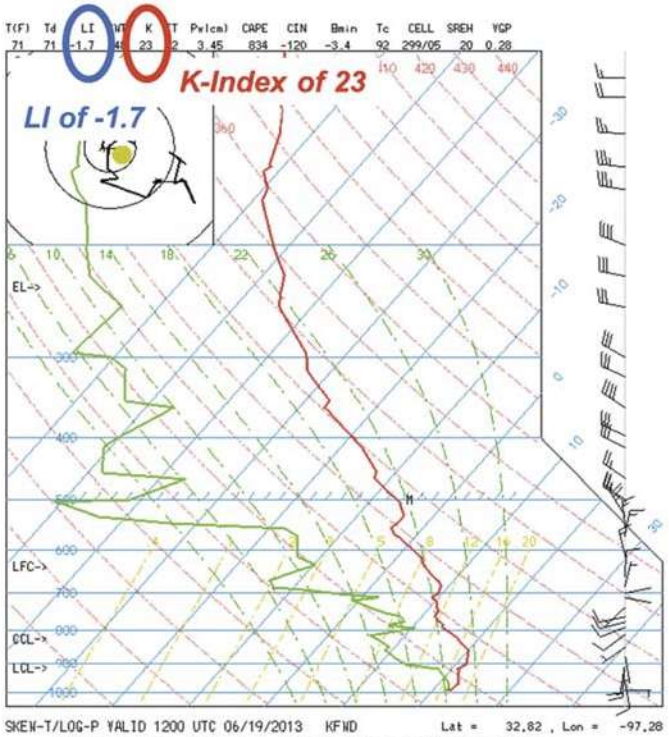


Chart #2: Upper Air Balloon Sounding For Fort Worth/Dallas

A negative Lifted Index indicates that the air closest to the ground is unstable with respect to the middle troposphere [See ***Text Box #1: Definitions***]. The more negative the LI the more unstable is the lower atmosphere, and convection can occur, i.e.; strong updrafts are likely to develop. While soaring flight needs some weak to moderate convection for thermal lift, too much instability can lead to overdevelopment in the form of thunderstorms and severe weather [See ***Table #1: Lifted Index Values and Atmospheric Instability***]. ☛

The K-Index provides an estimate of the likelihood of thunderstorms and subsequently, an estimate on the extent of the coverage. The first term in the K-Index Formula is the temperature lapse rate between the 850 mb level (approximately 5,000 ft Mean Sea Level, MSL) and the 500 mb level (approximately 18,000 ft MSL). The larger this temperature difference in the 850-to-500 mb layer then the trend is toward that layer being more unstable and supporting the development of convection or thermal lift. The remaining two terms of the K-Index Formula were designed to give an idea of lower atmosphere moisture content by looking at two mandatory reporting levels of the balloon sounding at 850 mb and 700 mb (approximately 10,000 ft MSL) rather than analyzing the entire balloon sounding. High water vapor content in the lower air layer combined with a good lapse temperature condition provides for thunderstorm development. The higher the K-Index then the probability of thunderstorms increases [See ***Table #2: K-Index and Coverage of General Thunderstorms***].

This Lifted Index Analysis Chart in the form displayed has not been generated at least since the 2009 time period (indications are that the last chart produced was March 16, 2009). Due to its longevity from the bygone facsimile machine era, reference to the *Lifted Index Analysis* Chart mistakenly has been left on NWS weather product lists even among relatively recent FAA and NWS publications. The primary government document for NWS weather products for the aviation community is *"Aviation Weather Services; Advisory Circular; AC 00-45"* [See ***Text Box #2: References***]. The March 12, 2009 publication date for Change Notice #2 for *AC 00-45F* still listed the *Lifted Index Analysis* Chart among the available products. But with the July 29, 2010, publication and distribution of the updated Advisory Circular, *AC 00-45G,* the *Lifted Index Analysis* Chart was no longer referenced as an available product. Even with the chart itself no longer available, the Lifted Index and K-Index still have some relevance in providing atmospheric instability information to the soaring pilot.

So if the reference indices are no longer available per the *Lifted Index Analysis* Chart, where can a soaring pilot find the information previously provided by that analysis chart? The answer for that question lies still with the original source of the indices as plotted on the defunct chart, the upper air or radiosonde balloon sounding plots [See ***Chart #2: Upper Air Balloon Sounding for Fort Worth/Dallas***]. On this sounding provided by the NWS and distributed on the web through the University of Wyoming, the top of the example plot for Fort Worth-Dallas (KFWD) displays the K-Index and the Lifted Index along with some other indices and parameters. While the reference indices computed from observed parameters are not available on a nationwide chart display, the calculated Lifted Index and the K-Index are nonetheless obtainable for each individual radiosonde balloon sounding plot.

The development and subsequent implementation of high-speed computers into numerical meteorological forecasting now enables updates of forecast atmospheric instability.

Table #2

K INDEX West of the Rockies	K INDEX East of the Rockies	Coverage of General Thunderstorms
less than 15	less than 20	None
15 to 20	20 to 25	Isolated thunderstorms
21 to 25	26 to 30	Widely scattered thunderstorms
26 to 30	31 to 35	Scattered thunderstorms
Above 30	Above 35	Numerous thunderstorms
Note: K value may not be representative of air mass if 850 mb level is near the surface.		

Table #2: K-Index and Coverage of General Thunderstorms
(Table 5-12. *Aviation Weather Services, FAA Advisory Circular 00-45F*)

Text Box #1

Definitions

Lifted Condensation Level
(Abbreviated, LCL) – The level at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

Troposphere
The layer of the atmosphere from the earth's surface up to the Tropopause and it is typically characterized by decreasing temperature with height (relatively thin inversion layers may form and dissipate), vertical wind motion, appreciable water vapor content, and sensible weather (clouds, rain, etc.).

Lifted Index
(Abbreviated, LI) – A common measure of atmospheric instability. Its value is obtained by computing the Lifted Condensation Level (LCL) of the air 50 millibars (mb) or approximately 150 feet above the surface of the ground and lifting it moist adiabatically to the 500 mb level, typically around 18,000 feet mean sea level (MSL), and subtracting that temperature from the actual temperature at that level. Negative values indicate instability; the more negative, the more unstable the air is, and the more buoyant the acceleration will be for rising parcels of air from the boundary layer next to the surface. (As an analogy for the soaring community, the LI is essentially a "Thermal Index" at the 500 mb level!) There are no absolute or threshold LI values below which severe weather becomes imminent. However, there are arbitrary ranges of LI values that describe the relative instability of the low to mid-troposphere [See Haby reference …..]

{LI = 500 mb environmental Temp – 500 mb lifted parcel temperature}

K-Index
The K-Index is a measure of the thunderstorm potential based on vertical temperature lapse rate, moisture content of the lower atmosphere, and the vertical extent of the moist layer. The temperature difference between the 850 mb level, typically around 5,000 feet MSL, and 500 mb is used to parameterize the vertical temperature lapse rate. The 850 mb dew point is used to represent the moisture content of the lower atmosphere. The vertical extent of the moist layer is represented by the difference of the 700 mb temperature and 700 mb dew point (DP). This is called the 700 mb temperature-dew point depression. The index is derived arithmetically and does not require a plotted sounding.

Note the following equation for the K-Index computation:

{K-Index = (850 mb Temp – 500 mb Temp) + 850 mb DP – 700 mb DP depression}

Through the auspices of the NWS's Storm Prediction Center (SPC), updated depictions of the Lifted Index and K-Index along with *numerous* other meteorological parameters and algorithms are produced by the Rapid Refresh hourly updated assimilation/modeling system. This information is then made available for display on the SPC Meso-scale Analysis Website [See ***Web Page #1: SPC Meso-scale Analysis Page***]. The SPC products displaying the Lifted Index [See ***Web Page #2: LI/Radar Chart***] and the K-Index [See ***Web Page #3: K-Index/Radar Chart***] involve model *forecast* projections of some parameters combined with recent *observations* ingested into the model run for the index computations. Despite combining *forecast* projections for some weather parameters and updated *observed* data for other parameters, a high degree of reliability for atmospheric stability evaluations results. During the 2012 World Gliding Championships at Uvalde, this combination of real-time observations and short-term parameter forecasts gave the weather forecast team a high confidence in its convection-threat assessments. The virtues of one such meso-scale analysis product, the *"Divergence Chart,"* utilizing this assimilation/modeling process, were discussed in the December 2012 issuance of *Soaring*.

In summary, understanding the background to selected weather analysis and forecast products can provide insight for the educated soaring pilot to assess atmospheric stability (instability) potential. In the case of the Lifted Index and the K-Index computed from direct observations or derived in the Rapid Refresh Numerical Modeling, the projected indices provide information for soaring as well as severe weather potential for safety-of-flight deliberations.

Text Box #2

References

Websites:

"*Skew-T Basics*", Courtesy of Meteorologist Jeff Haby
<http://www.theweatherprediction.com/thermo/skewt/ >

"Skew-T: A Look at LI"; Courtesy of Meteorologist Jeff Haby
<http://www.theweatherprediction.com/habyhints/300/ >

Upper Air Data (Raobs); University of Wyoming
< http://weather.rap.ucar.edu/upper/ >

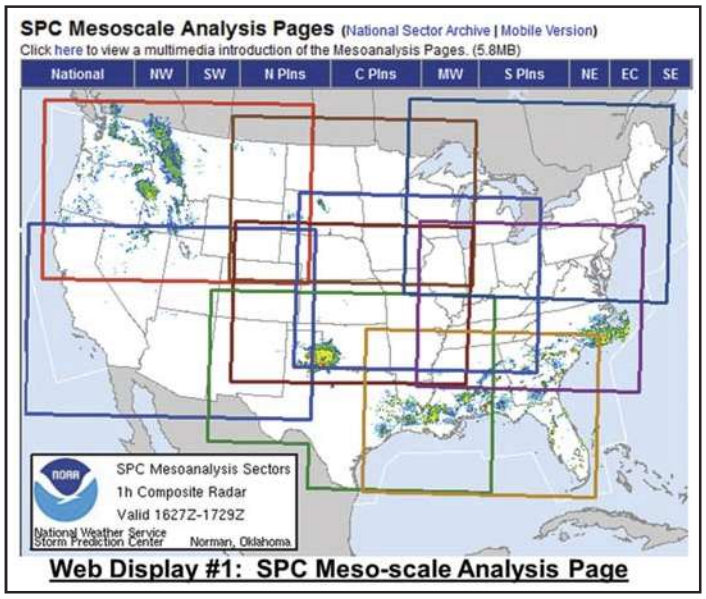
NWS Glossary of Meteorology
< http://w1.weather.gov/glossary/ >

NWS Storm Prediction Center; Meso-scale Analysis Page
<http://www.spc.noaa.gov/exper/mesoanalysis >

Gov't Printing Office: "*FAA Advisory Circular 00-45F" (Change 2; Mar 12, 2009)*
<http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%2000-45F.pdf >

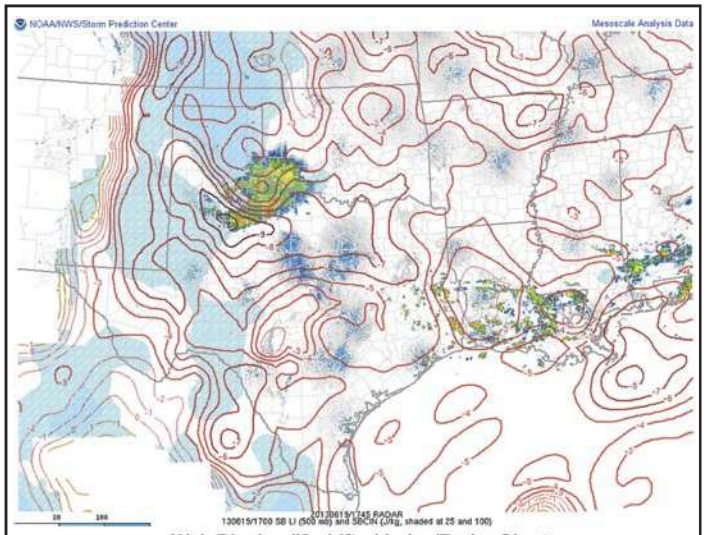
Gov't Printing Office: *"FAA Advisory Circular 00-45G" (Published July 29, 2010)*
<*http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC-0045G_chg1_fullDocument.pdf* >

Web Chart #1



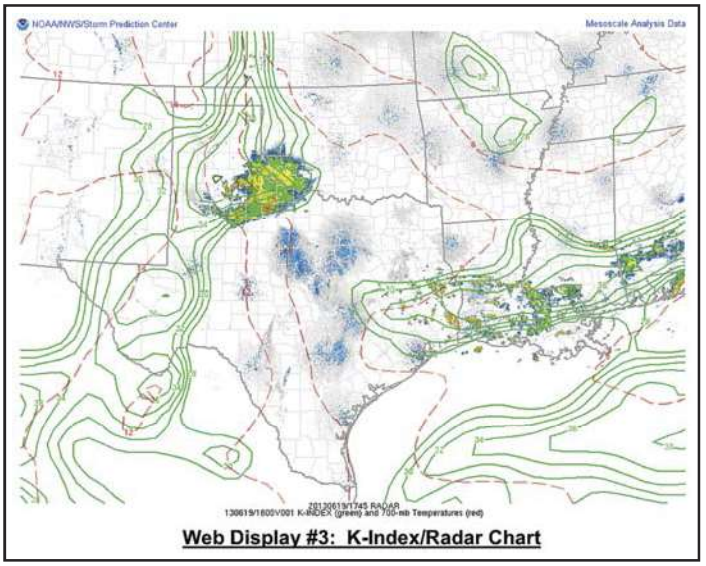
Web Display #1: SPC Meso-scale Analysis Page

Web Chart #2



Web Display #2: Lifted Index/Radar Chart

Web Chart #3



Web Display #3: K-Index/Radar Chart