Convective Season Parameters and Indicies

Taken from: www.crh.noaa.gov/lmk/soo/docu/indices.htm

1. Evaluation of Stability

Lapse rate: Refers to the rate of temperature change with height in the atmosphere. A steep lapse rate is one in which the environmental temperature decreases rapidly with height. The steeper the environmental lapse rate, the more potentially unstable is the atmosphere.

Let LR(e) = Environmental lapse rate
Let LR(p) = Parcel lapse rate.
Let LR(da) = Dry adiabatic lapse rate (dry ascent).
Let LR(ma) = Moist adiabatic lapse rate (saturated ascent).

For dry/unsaturated convection, LR(p) = LR(da).
For moist/saturated convection, LR(p) = LR(ma).

- **Absolute stability:**
  LR(e) < LR(p) (Parcel lapse rate has a steeper slope than the environment, i.e., parcel is cooler than the surrounding environment).
- **Neutral stability:**
  LR(e) = LR(p) (Parcel lapse rate has the same slope as the environment).
- **Absolute instability:**
  LR(e) > LR(p) (Parcel lapse rate has less slope than the environment, i.e., parcel is warmer than the surrounding environment).
- **Conditional instability:**
  Exists when the environmental lapse rate curve LR(e) is between the dry [LR(da)] and moist [LR(ma)] adiabatic lapse rate curves on a SkewT-LogP diagram. In these cases, the atmosphere is unstable with respect to saturated (the "condition") parcel ascent [i.e., LR(p) = LR(ma)] since the rising parcel will be warmer than the environment.
- **Potential (convective) instability:**
  Exists when Qe or Qw (equivalent and wet bulb potential temperature, respectively) decreases with height (dQe/dz < 0). When this occurs, an initially stable layer will destabilize as it is lifted, since the top of the layer will cool faster than the bottom, thereby steepening the lapse rate. In reality, whole layers may not be lifted at once; instead, parcels often lift from the boundary layer to their level of free convection (LFC) to form thunderstorms. Thus, the physical process that potential instability represents may or may not occur often during convection. However, Qe (which is more sensitive to moisture than temperature) decreasing with height IS important, since it represents the presence of dry air above moist air which enhances downburst and possibly hail potential if thunderstorms develop.

2. Evaluation of Moisture

An evaluation of moisture is critical for determining the potential for convection, severe weather, and heavy rainfall. Thunderstorms can develop in an area of significant ambient or inflow moisture. In evaluating moisture, consider the surface to 700 mb dewpoints, 1000-500 mb precipitable water (PW), the K index, and moisture convergence. During the warm season, rough threshold values (and higher values representing better potential) for heavy rain include:

    - **Surface dewpoint:** 60 F (70 F)
    - **850 mb dewpoint:** 10-12 C (14 C)
- **700 mb moisture:** Can be moist or relatively dry for heavy rain and severe weather. However, moisture increases precipitation efficiency, while dry air (dewpoint depression roughly 10 C or more) increases convective instability and downburst/hail potential.
    - **1000-500 mb PW:** 1.0 inch (1.5 inches)
- **K index:** 30 (35). K values will be lower if dry air is present at 700 mb, but severe weather or even heavy rain still can occur (see K index section).

These are rough numbers and heavy rain or severe weather may still occur at values below these, especially if significant forcing is present, or during the cool season.

3. Total Totals Index (TT)

The Total Totals Index consists of two components, the Vertical Totals (VT) and the Cross Totals (CT). The VT represents static stability or the lapse rate between 850 and 500 mb. The CT includes the 850 mb dewpoint. As a result, TT accounts for both static stability and 850 mb moisture, but would be unrepresentative in situations where the low-level moisture resides below the 850 mb level. In addition, convection may be inhibited despite a high TT value if a significant capping inversion is present.

TT = VT + CT
VT = T(850 mb) - T(500 mb)
CT = Td(850 mb) - T(500 mb)

in degrees C, where T represents temperature at the indicated level and Td represents dewpoint temperature.

VT = 40 is close to dry adiabatic for the 850-500 mb layer. However, VT generally will be much less, with values around 26 or more representing sufficient static instability (without regard to moisture) for thunderstorm occurrence. CT > 18 often is necessary for convection, but it is the combined Total Totals Index that is most important.

TT = T(850 mb) + Td(850 mb) - 2[T(500 mb)] in degrees C.

TT = 45 to 50: Thunderstorms possible.
TT = 50 to 55: Thunderstorms more likely, possibly severe.
TT = 55 to 60: Severe thunderstorms most likely.

4. Delta-T Index (DTI)/700-500 mb Lapse Rate

These parameters assess the contribution of middle-level lapse rate to convective instability. A steep 700-500 mb lapse rate overtop low-level moisture is quite favorable for strong/severe convection including microbursts and hail. The DTI measures the temperature difference between two mandatory pressure levels (often 700-500 mb). The DTI is similar to the Vertical Totals.

10.2 deg C/km: Dry adiabatic lapse rate (700-500 mb)

DTI = 26 deg C in warm season:	Dry adiabatic lapse rate (700-500 mb)
6.5 C/km for 700 mb temp = 0 C:	Moist adiabatic lapse rate (700-500 mb)
6.0 C/km for 700 mb temp = +5 C:	Moist adiabatic lapse rate (700-500 mb)
5.6 C/km for 700 mb temp = +10 C:	Moist adiabatic lapse rate (700-500 mb)
DTI = 18 C in warm season:	Moist adiabatic lapse rate (700-500 mb)

5. K Index

The K index is a measure of thunderstorm potential based on the vertical temperature lapse rate, and the amount and vertical extent of low-level moisture in the atmosphere.

K = T(850 mb) + Td(850 mb) - T(500 mb) - DD(700 mb)

in degrees C, where T represents temperature, Td represents dewpoint temperature, and DD represents dewpoint depression at the indicated level.

K below 30:	Thunderstorms with heavy rain or severe weather possible (see note below).
K over 30:	Better potential for thunderstorms with heavy rain.
K = 40:	Best potential for thunderstorms with very heavy rain.

In general, the higher the ambient or inflow K index value, the greater the potential for heavy rain. However, beware of low (less than 30) values of K. Since the K index includes the dewpoint depression (i.e., difference between the temperature and dewpoint temperature) at 700 mb, dry air at this level will cause a low K value. However, given moisture below 700 mb, unstable air, and a lifting mechanism, strong or severe organized thunderstorms, and even heavy rain, can still occur. Scattered diurnal convection occurring in an environment containing high K (and PW) values can cause a quick burst of very heavy rain.

6. Lifted Index (LI)

The LI is a commonly utilized measure of stability which measures the difference between a lifted parcel's temperature at 500 mb and the environmental temperature at 500 mb. It incorporates moisture and lapse rate (static stability) into one number, which is less vulnerable to observations at individual pressure levels. However, LI values do depend on the level from which a parcel is lifted, and rally cannot account for details in th environmental temperature curve above the LCL and below 500 mb. LI was originally intended to utilize average moisture and temperature properties within the planetary boundary layer.

LI = T(500 mb envir) - T(500 mb parcel)

in degrees C, where T (500 mb envir) represents the 500 mb environmental temperature and T (500 mb parcel) is the rising air parcel's 500 mb temperature.

LI over 0:	Stable but weak convection possible for LI = 1-3 if strong lifting is present.
LI = 0 to -3:	Marginally unstable.
LI = -3 to -6:	Moderately unstable.
LI = -6 to -9:	Very unstable.

LI below -9:	Extremely unstable.

These LI values are based on lifted parcels using the average lowest 50 to 100 mb moisture and temperature values (i.e., the boundary layer). Variations exist on how LI values are calculated, as discussed below.

Surfaced-based LI: Surface-based LIs can be calculated hourly, and assume a parcel is lifted from the surface using surface-based moisture and temperature values, as well as assigned environmental temperatures at 500 mb. This method is valid for a well-mixed nearly dry adiabatic afternoon boundary layer where surface characteristics are similar to those in the lowest 50 to 100 mb layer. However, these values would not be representative of the ambient elevated instability if a nocturnal inversion or shallow cool air to the north of a frontal boundary is present. In these cases, more instability resides above the surface, and parcels may be lifted to form thunderstorms from the top of the inversion.

Best LI: The Best LI represents the lowest (most unstable) LI computed from a series of levels from the surface to about 850 mb. This index is most useful during cases when shallow cool air exists north of a frontal boundary resulting in surface conditions and boundary layer-based LI values that are relatively stable. However, the airmass at the top of the inversion, from which lifting may occur, is potentially unstable. An example of this would be elevated ("overrunning") convection (possibly a nocturnal MCS).

7. Showalter Index (SI)

The SI is based on the properties of the 850 and 500 mb levels. The SI is calculated by lifting a parcel dry adiabatically from 850 mb to its LCL, then moist adiabatically to 500 mb, and comparing the parcel versus environmental 500 mb temperatures similar to the LI. The SI may be better than the LI in showing instability aloft given a shallow low-level cool airmass north of a frontal boundary. However, the SI is an unrepresentative index and inferior to the LI in showing instability if the low-level moisture does not extend up to the 850 mb level.