General thunderstorm stability indexes (indices)

Stability Indices

- Stability indices can be calculated using temperatures, dew point temperatures, and winds from a few mandatory levels of a radiosonde sounding.
- Purpose:
  - to obtain a number to provide some measure of the overall stability of the atmosphere.
  - to evaluate the potential for severe weather / predict thunderstorms to occur

However…

- Since they are only calculated using a few levels of the sounding, many details on the soundings are not accounted for.
- Sounding is a snapshot of the atmosphere. Stability indices calculated from sounding would not tell us how the atmosphere is going to evolve later on. Often use model soundings in applications.

Important Points to Remember

- Severe weather is more dependent on dynamical forcing than instability!
- No one parameter tells the full tale! And some on any given day fail. Best to look at many to synthesize a view of the atmosphere’s stability
- 12z soundings usually predict afternoon convection better than 00z
- 00z soundings predict evening convection better.

Index Name	Formula (Except for CAPE, T is in °C)	Comments
Showalter index	$\mathrm{SI} = T_{500} - T_{lp(850)}$	Quantifies parcel instability lifted from 850 mb to 500 mb. But can miss info below 850-mb and inversions. Only uses two pts
Lifted index	$\mathrm{LI} = T_{500} - T_{lp(fcst\ sfc)}$	Similar to SI and has same faults, but does have sfc info. Mean sfc layer versions exist. Best LI (BLI) is largest LI for all low levels
K-index	$\mathrm{K} = (T_{850} - T_{500}) + T_{D\,850} - (T_{700} - T_{D\,700})$	Used for air mass thunderstorm POP. Does not work well, but may provide an upper bound to POP
Convective available potential energy	$\mathrm{CAPE} = \int_{LFC}^{EL} g\left(\frac{T_{parcel} - T_{env}}{T_{env}}\right) dz$	Total amount of energy available to a parcel after being lifted to its LFC. Entrainment and water loading are not considered.
Vertical totals	$\mathrm{VT} = T_{850} - T_{500}$	Represents 850-mb to 500-mb lapse rate. Steeper slopes have higher VT values and indicate larger instability.
Cross totals	$\mathrm{CT} = T_{D\,850} - T_{500}$	Combines 850-mb moisture with 500-mb temperature. Moist low-level and cold mid-level yields large CT values.
Total totals	$\mathrm{TT} = \mathrm{VT} + \mathrm{CT}$	
SWEAT index	$\mathrm{SWEAT} = 20(\mathrm{TT}-49°\mathrm{C}) + 12T_{D\,850} + 2V_{850} + V_{500} + 125[\sin(V_{500} - V_{850}) + 0.2]$	Combines five terms which correlate to severe weather: 1) 850-mb moisture; 2) Instability (TT); 3) Low-level jet at 850 mb; 4) Mid-level wind at 500 mb; 5) Warm advection and wind shear (veering between 850 mb and 500 mb) This was the first term developed to differentiate severe thunderstorms from ordinary thunderstorms. Many more have since been developed for severe weather (to be discussed in another lecture) Wind has to be in knots. Any term <0 is set to zero. The shear term (V_{500}-V_{850}) is set to zero if: V_{850} is not from 130-250°; V_{500} is not from 210-310°; V_{500}-V_{850} <0; V_{500} or V_{850} < 15 kts; or $T_{D\,850}$ <0°C

lp indicates “lifted parcel” from a given level.

While a sounding is a good glance at 00Z or 12Z conditions, using forecast soundings from models is a better use of the indexes

Stability categories and likelihood of severe convective storms for various ranges of the Lifted Index (LI), Showalter Index (SI), Convective Available Potential Energy (CAPE), Total Totals (TT) index, and SWEAT (SW) index.

Stability	LI	SI	CAPE	TT	SW
Very stable (no significant activity)	> +3				
Stable (Showers possible; T'showers unlikely)	0 to +3	> +2	< 0		
Marginally unstable (T'showers possible)	–2 to 0	0 to 2	0 to 1000	45 to 50	
Moderately unstable (Thunderstorms possible)	–4 to –2	–3 to 0	1000 to 2500	50 to 55	250 to 300
Very unstable (Severe T'storms possible)	–6 to –4	–6 to –3	2500 to 3500	55 to 60	300 to 400
Extremely unstable (Severe T'storms probable; tornadoes possible)	< –6	< –6	> 3500	> 60	> 400

- Many stability indexes have been developed since 1953
- Some are obscure, obsolete, or modified
- New ones still being developed

The Storm Prediction Center Mesoscale Analyses website contains a nice synthesis

http://www.spc.noaa.gov/exper/mesoanalysis/

Soundings with indexes

http://weather.unisys.com/upper_air/skew/
http://www.wxcaster.com/etaskewts.htm
http://www.spc.noaa.gov/exper/soundings/