ATMO 352
Severe Weather and Mesoscale Forecasting
Spring 2007

Laboratory #9

CAPE and Shear in Thunderstorms and Severe Storms

Section 502, Friday
3-23-07

Due: by the beginning of the next lab session (3-30-07)

Internet resource:

http://www.spc.noaa.gov/exper/archive/events/searchindex.html

Complementary Reading:

You should review the reading on the role of CAPE and shear that has already been assigned. See http://www.met.tamu.edu/class/atmo352/atmo352_spring07_reading.pdf

Introduction:

In your reading and in lecture, we are exploring how CAPE and "deep layer" shear (0-6 km) control convective cell type (i.e., ordinary multicell vs. supercell). In general, increasing CAPE and 0-6 km shear are associated with an increasing probability of supercell convection (e.g., see Table 3.2 from Bluestein (1993) in your lecture materials). Furthermore, we also know that supercells are prodigious producers of severe weather, including large hail (≥ 3/4 inch), strong straight-line winds (≥ 50 kts), and possibly tornadoes. In fact, forecasters typically associate increasing CAPE and 0-6 km shear with an increasing probability of severe convective weather.

Unfortunately, several studies of proximity soundings associated with severe storm and supercell environments have shown that CAPE and 0-6 km shear only *weakly* distinguish between ordinary cells and supercells (Rasmussen and Blanchard 1998, Weather and Forecasting) or thunderstorms and severe storms (Craven et al. 2002, 21st Conference on Severe Local Storms) when used *individually*. However, when using both CAPE and shear *simultaneously* in a combined parameter, the results showed a noticeable improvement. Calculating the *product* of mixed layer CAPE (MLCAPE) and 0-6 shear (i.e., [MLCAPE] * [0-6 km Δv], which gives units of $m^2\ s^{-2} * m\ s^{-1} = m^3\ s^{-3}$) provided reasonable separation between thunderstorms and severe storms when analyzing over 60,000 proximity soundings, severe storm data, and National Lightning Detection Network (NLDN) cloud-to-ground lightning data from 1997-1999 (Craven et al. 2002). As shown in Figure 1 below from Craven et al. (2002), the product of MLCAPE and 0-6 km shear yielded only a small overlap between the middle 50 percent of the thunderstorm and severe storm distributions, especially for the significant severe storms (i.e., ≥

2” hail or ≥ 65 kts wind gust) or significant tornadoes (i.e., F2-F5). Notice that the majority of significant severe events occur when the combined CAPE*shear parameter exceeds about 20,000 m^{-3} s^{-3}. As a result, this parameter is sometimes called the *Craven/Brooks Significant Severe* parameter (e.g., at the SPC Forecast Tools web site).

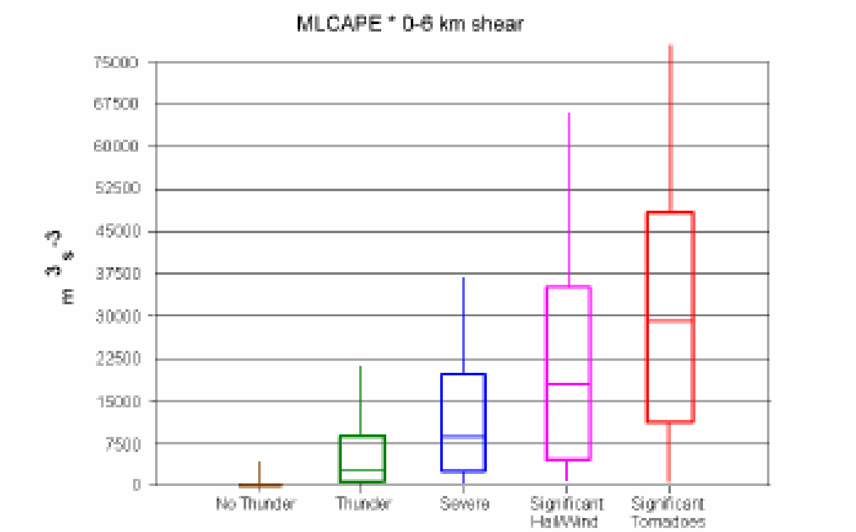

Figure 2. As in Fig. 1, except for product of MLCAPE and 0-6 km shear.

Figure 1. Box and whisker plot for the product of mean layer CAPE (MLCAPE) and 0-6 km shear. 10th, 25th, 50th, 75th, and 90th percentiles are shown. From Craven et al. (2002). See Table 1 below for definitions of the five categories.

Table 1. Definitions and number of proximity soundings for the five convective categories

Number	Category		Definition
45508	No Thunder		0-1 CG strikes
11339	General Thunder		≥ 2 CG strikes
2644	Severe		0.75-1.99" hail
		and/or	50-64 knot gust
		and/or	wind damage
		and/or	F0 or F1 tornado
512	Significant Hail/Wind		≥ 2.00" hail
		and/or	≥ 65 knot gust
87	Significant Tornadoes		F2-F5

(From Craven et al. 2002)

Background:

Since January 2000, NSSL has maintained an archive of environmental data associated with severe convective weather events: http://www.spc.noaa.gov/exper/archive/events/searchindex.html

We will utilize this data resource to record and evaluate the efficacy of MLCAPE, 0-6 km shear, and their product in distinguishing between thunderstorm and severe storm environments during the warm season (April – September) during 2006. Each event day includes a map of severe storm reports and upper air sounding data with analysis of MLCAPE and 0-6 km shear. The severe storm report map can be found by selecting "Storm Reports" and then "SPC Preliminary." The sounding data can be obtained by selecting "Upper Air" and then "Skew-T/Log-P Plots." You can select the time of the soundings by using the scroll bar in the upper left hand side of the display. We will use 00 UTC soundings exclusively for this assignment. Note that MLCAPE (J kg^{-1}) and 0-6 km shear (kts) is given next to the Skew-T diagram. Using these maps of severe storm reports and Skew-T Log-P diagrams, we will obtain MLCAPE and 0-6 km shear data in close proximity to severe storms. Finally, the archive shows the plotted location of all cloud-to-ground lightning flashes during the event. Select "SPC products" and then select the one of the archived Day 1 Outlooks (e.g., 06Z). The blue minus/plus marks (**-/+**) indicate the location of (negative/positive polarity) cloud-to-ground lightning during the 24-hour period starting at 12z. Using the map of lightning locations and severe storm reports, we can identify soundings associated with CG lightning but NOT severe storm reports (i.e., thunderstorm or non-severe storms).

Using this database, we can analyze the effectiveness of MLCAPE, 0-6 km shear and their product for distinguishing between severe storms and thunderstorms. You can also compare your results to Craven et al. (2002) shown above. We will add your 2006 results to those of past ATMO 352 classes (i.e., 2002-2005 is already done) to evaluate the usefulness and typical range of the Craven/Brooks Significant Severe parameter in severe and non-severe storms.

Exercises (40 points):

You will be assigned a specific month to analyze (e.g., May 2006). You may use data from any event day within your assigned month during 2006.

1. (15 points) Identify *five* (5) distinct **00 UTC** soundings in close proximity to severe storm reports on at least two different event days during your assigned month. For the purpose of this laboratory assignment, we will consider a 00 UTC sounding to be in close proximity to a severe storm report if it is within *roughly* 175 km (or about 1.5° of latitude/longitude). You can estimate how close each sounding is to severe storm reports by eye (i.e., approximately). If you are not sure how big 1.5° is, then you can display a CONUS map using GARP and plot 1.5° grid boxes on it. *Bottom line*: Estimate the distance by eye and if you are not sure, use soundings that are clearly within severe storm areas.

a. (10 points) To organize your five severe storm soundings, create a table that includes the date, the three letter identifier of the sounding site, the MLCAPE ($m^2 s^{-2}$), the 0-6 km shear (Δv, $\mathbf{m\ s^{-1}}$; note: 1 kt = 0.514 m s^{-1}), and the product of MLCAPE and 0-6 km shear ($m^3 s^{-3}$). Watch units! Note: In addition to handing in your lab, you must **e-mail** this table to larry_carey@tamu.edu by the due date to get credit.

b. (1 point) Calculate the mean of the MLCAPE, the 0-6 km shear, and the product of MLCAPE and 0-6 km shear for the severe storm soundings.

c. (4 points) Compare your MLCAPE * 0-6 shear values in severe storms to those of Craven et al. (2002) shown in Figure 1 above. Note that Craven et al (2002) separates severe weather into a few different categories (see Table 1). Discuss possible reasons for any differences.

2. (15 points) Identify five (5) distinct **00 UTC** soundings that are in close proximity to cloud-to-ground lightning locations but *NOT* severe storm reports on at least two different event days during your assigned month, using the same definition of "close proximity" as described above.

a. (10 points) To organize your five "thunderstorm" or "non-severe" soundings, create a table that includes the date, the three letter identifier of the sounding site, the MLCAPE ($m^2 s^{-2}$), the 0-6 km shear ($m s^{-1}$), and the product of MLCAPE and 0-6 km shear ($m^3 s^{-3}$). Note: In addition to handing in your lab, you must **e-mail** this table to larry_carey@tamu.edu by the due date to get credit.

b. (1 point) Calculate the mean of the MLCAPE, the 0-6 km shear, and the product of MLCAPE and 0-6 km shear for the thunder soundings.

c. (4 points) Compare your MLCAPE * 0-6 shear values in thunderstorms to those of Craven et al. (2002) shown in Figure 1 above. Discuss possible reasons for any differences.

3. (5 points) Using your results from 1) and 2) above, evaluate the relative effectiveness of MLCAPE, 0-6 km shear, and the product of MLCAPE and 0-6 km shear in differentiating thunderstorm and severe storm environments.

4. (5 points) Explain in *physical terms* why MLCAPE, 0-6 km shear, and the product of MLCAPE and 0-6 km shear may or may not be effective in distinguishing between thunderstorms and severe storm environments.