ATMO 352
Severe Weather and Mesoscale Forecasting
Spring 2007

Laboratory #7: Severe Thunderstorm Climatology

Section 502, Friday
3-2-07

Due: By beginning of next lab session (3-9-07)

Internet html address for lab resource: http://www.nssl.noaa.gov/hazard/

Introduction:

At NOAA's National Severe Storms Laboratory, Dr. Harold Brooks and collaborators (Brooks et al. 2003, *Weather and Forecasting*) have completed a project to estimate the likelihood of severe weather hazards in the United States, which updates and extends earlier work (e.g., Kelly et al. 1978, 1985; *Monthly Weather Review*). Some of the severe thunderstorm climatology from this study can be viewed online at http://www.nssl.noaa.gov/hazard/ .

Of course, severe thunderstorms are defined by NOAA/NWS in the United States as having either tornadoes, straight line wind gusts of at least 58 mph (50 kts or 25.7 m s^{-1}), or hail size of at least 3/4 inch (1.9 cm) in diameter. The available online figures are of three primary kinds:

1. The average number of days per year with the event occurring within 25 miles of any point (Total Threat).
2. Animated loops of the probability of severe weather occurring within 25 miles of any point on a particular day with images once per week through the year (Animated Loops).
3. Graphs showing the annual cycle of the probability of severe weather occurring within 25 miles at any point you select (Annual Cycles at Points [Clickable Maps]).

Some of the figures and animations also document the climatology of so-called "High-End" severe weather such as significant tornadoes (F2 or greater), violent tornadoes (F4 or F5), very strong wind gusts (≥ 65 kts), and very large hail (diameter ≥ 2 inches). Finally, there are also some miscellaneous results that address when the maximum threat is for a given location for each severe storm category, monthly probabilities of each severe storm type, the variability of the date of the maximum threat of tornadoes by location, and the change in event frequency from the 1980's to the 1990's. A more detailed explanation of methods and results from the study can be found in Brooks et al. (2003).

Background Information:

The severity of hailstorms and straight line wind (non-tornadic) events are classified in a straightforward manner according to the hail size (e.g., usually diameter in mm or inches) and wind gust speed (e.g., mph, kts, or m s^{-1}) respectively. Although an imperfect measure of tornadic intensity, tornadic storms are classified according to the damage that they cause and the *estimated* tornadic wind speed that is assumed to be associated with the damage assessment. In the past, the most widely used damage scale was the "*Fujita Tornado Damage Scale*" or "*F-scale*" (F0, F1, F2, F3, F4, F5), where increasing F-scale values imply increasing tornadic damage. The F-scale was developed in 1971 by Prof. T. Theodore Fujita of the University of Chicago. A long awaited update to the F-scale called the *Enhanced F-scale (EF)* for tornado damage was recently completed by a team of wind engineers and meteorologists and implemented in February 2007.

Source: http://www.spc.noaa.gov/efscale/ef-scale.html

FUJITA SCALE			**OPERATIONAL EF SCALE**	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	**EF Number**	**3 Second Gust (mph)**
0	40-72	45-78	**0**	**65-85**
1	73-112	79-117	**1**	**86-110**
2	113-157	118-161	**2**	**111-135**
3	158-207	162-209	**3**	**136-165**
4	208-260	210-261	**4**	**166-200**
5	261-318	262-317	**5**	**Over 200**

Although the F-scale and EF-Scale damage ratings are the same, note that the estimated wind speed ranges are different.

***** IMPORTANT NOTE ABOUT ENHANCED F-SCALE WINDS:** *The Enhanced F-scale still is a set of wind estimates (not measurements) based on damage*. Its uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the 28 indicators located at the following Internet site: http://www.spc.noaa.gov/efscale/ef-scale.html . These estimates vary with height and exposure. **Important**: The 3 second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured, "one minute mile" speed.

Exercises (60 points):

Use the image data and animated loops at the NSSL Internet site given above to answer the following questions.

1. (*9 points*) **Tornado Threat**
    a. (*2 points*) Using data from 1980-1999, describe the general location(s) of the frequency maxima of tornado days per year. What are typical values within the maxima?
    b. (*4 points*) Repeat the same procedure and questions in 1a) above for significant (F2 or greater) and violent (F4 or F5) tornadoes, using data from 1921-1995. Be sure to show units with typical values.
    c. (*3 points*) What differences do you notice between the annual climatology of the frequency of occurrence of all, significant, and violent tornadoes?

2. (*7 points*) **Straight Line Wind Threat**
    a. (*2 points*) Repeat procedure and questions in 1a) above but for severe thunderstorm winds.
    b. (*2 points*) Repeat procedure and questions in 1b) above but for winds ≥ 65 kts, using data from 1980-1994.
    c. (*3 points*) What differences do you notice between the annual climatology of the frequency of occurrence of >50 kts and 65 kts straight line wind events?

3. (*7 points*) **Hail Threat**
    a. (*2 points*) Repeat procedure and questions in 1a) above but for severe hail events.
    b. (*2 points*) Repeat procedure and questions in 1b) above but for hail diameter ≥ 2 inches, using data from 1980-1994.
    c. (*3 points*) What differences do you notice between the annual climatology of the frequency of occurrence of ≥ 3/4" and ≥ 2" hail?

4. (*6 points*) Using weekly animations from 1980-1994, describe in general terms the **annual march** (or movement) of any (i.e., all) **severe weather** probability across the contiguous United States. In your answer, describe in general where the overall peak(s) (i.e., primary, and if any, a secondary maximum) of severe activity is (are) during each of the calendar months. Since the animation is roughly by week, use the first week of each month to describe location(s) of peak(s).

5. (*12 points*) Using weekly animations from 1980-1999, answer the following questions regarding the **annual cycle of tornadoes, large hail, and severe winds**:
    a. (*4 points*) Approximately when (week, month) and where is the peak in tornado (any) probability of occurrence over Florida (i.e., assessed from both magnitude of probability and coverage of peak magnitude)? Colorado? Texas?
    b. (*4 points*) Where is the peak probability of occurrence of severe hail (≥ ¾") during the last week in March (e.g., 03/25), first week in June (06/03), 2nd week in

July (07/08), and 2nd week in October (10/14)? What do you notice about the path of severe hail probability maximum during this period (March – October)?

c. (*4 points*) How does the annual cycle of severe wind (≥ 50 kts) compare east of the Mississippi river to the region west of the Mississippi river (as far west as the Continental Divide).

6. (*7 points*) Using weekly animations (i.e., first week of each month) from 1921-1995, answer the following questions regarding the **annual cycle of significant** (F2-F5) and **violent** (F4 or F5 only) **tornadoes**:
   a. (*5 points*) Where is (are) the most likely (i.e., peak in probability of occurrence) location(s) of significant tornadoes during each month from February – August? Which of those months has the lowest probability of occurrence of significant tornadoes?
   b. (*2 points*) Where is (are) the most likely location(s) of violent tornadoes during March and May?

7. (*9 points*) Using the point-and-click interface for the Time Series of Annual Cycle of Tornado, Wind, and Hail Probability, let's explore the **annual cycle of severe weather in the approximate vicinity of College Station, Texas (CLL)**. Use the average (black) curve to answer each question unless otherwise specified.
   a. (*2 points*) When is (are) the peak(s) in tornado (all) activity over CLL? What is the probability of the overall peak? Note that the dates are listed by Julian Day. Julian Day (JD) is just the numerical day of the year with Jan 01 starting as JD 1 and December 31 being JD 365 (for non-leap years of course). For example, the 1st of May during non-leap years is JD 121. See http://angler.larc.nasa.gov/armsgp/JulianDayChart.html for a chart converting Julian Day to day and month.
   b. (*2 points*) Repeat a) for severe hail.
   c. (*2 points*) Repeat a) for severe wind gusts.
   d. (*3 points*) Repeat a) for significant tornadoes. When is secondary peak in significant tornadoes over CLL?

8. (*3 points*) Using the link to "Miscellaneous Climatological Information," explore the concept of "**Tornado Alley**." After reading the material and viewing the figures, provide a definition for the Tornado Alley of significant tornadoes according to Dr. Brooks and colleagues? Be sure to explain 1) what it is and 2) where it is.