



# SCIENCE DISSECTED

## *Increased Tornado Activity in the United States Model-Evidence Link Diagram (MEL)*

Reliable scientific data on tornado recordings have only existed in the United States since the 1950s. Prior to the 1950s tornadoes were, for most, dark and mysterious menaces of unfathomable power, fast-striking monsters from the sky capable of sudden and unpredictable acts of death and devastation. Since 1950, when the Weather Bureau revoked the ban on mentioning tornadoes in forecasts, as well as weather patterns which led to major tornado events became better documented and researched, there has been an increase in tornado activity in the United States (Source: <http://www.spc.noaa.gov/faq/tornado>). It remains unclear if increased recordings are directly linked to climate change or of more advanced monitoring equipment. This issue of Science Dissected provides an instructional resource for teachers to present students with the opportunity to examine several pieces of evidence compiled about tornado activity and critically evaluate two competing models of increased tornado activity;

**Model A:** *An increase in recorded U.S. tornado activity is due to climate change in Earth's atmospheric system.*

**Model B:** *An increase in recorded U.S. tornado activity is due to a more populated U.S. and better weather monitoring equipment.*

**Evidence #1:** The annual number of tornadoes has been increasing in the U.S. for the past 50 years. During this same time period, Earth's average surface temperature has been increasing as well.

**Evidence #2:** An increase in Doppler radar coverage and greater attention to reporting tornadoes has caused an increase in tornado records.

**Evidence #3:** Tornado outbreaks in the U.S. are stronger and more frequent after winter periods of cooler Pacific sea surface temperatures (La Nina).

**Evidence #4:** The Mid-West populations of the United States have increased significantly in the past 100 years.

### **The following is a suggestion for using this MEL with students:**

1. Hand out the Increased Tornado Activity Model Evidence Link Diagram (page 1). Instruct students to read the directions, descriptions of Model A and Model B, and the four evidence texts presented.
2. Handout the four evidence text pages (pages 3-6).
3. Instruct students to carefully review the Evidence #1 text page (page 3), then construct two lines from Evidence #1; one to Model A and one to Model B. Remind students that the shape of the arrow they draw indicates their plausibility judgment (potential truthfulness) connection to the model.
4. Repeat for Evidence #2-4 (pages 4-6).
5. Handout page 2 for the students to critically evaluate their links and construct understanding.

Once students have completed page 2, they can then engage in collaborative argumentation as they compare their links and explanations with that of their peers. Students should be given the opportunity to revise the link weighting during the collaborative argumentation exercise. If time permits, have students reflect on their understanding of tornado activity and create questions that they might explore in the future.

Name: \_\_\_\_\_ Period: \_\_\_\_\_

**Directions:** draw two arrows from each evidence box. One to each model. You will draw a total of 8 arrows.

**Key:**

	The evidence <b>supports</b> the model
	The evidence <b>STRONGLY supports</b> the model
	The evidence <b>contradicts</b> the model (shows its wrong)
	The evidence has <b>nothing to do with</b> the model

Standard: E.8.A.4

**Evidence #1: The annual number of tornadoes has been increasing in the United States for the past 50 years. During this same time period, Earth's average surface temperature has been increasing as well.**

**Model A**  
An increase in recorded U.S. tornado activity is due to climate change in Earth's atmospheric system.

**Evidence #3: Tornado outbreaks in the United States are stronger and more frequent after winter periods of cooler Pacific sea surface temperatures (La Nina).**



**Evidence #2: An increase in Doppler radar coverage and greater attention to reporting tornadoes has caused an increase in tornado records.**

**Model B**  
An increase in recorded U.S. tornado activity is due to a more populated United States and better weather monitoring equipment.

**Evidence #4: The Mid-West populations of the United States have increased significantly in the past 100 years.**

Provide a reason for three of the arrows you have drawn. **Write your reasons for the three most interesting or important arrows.**

- A. Write the number of the evidence you are writing about.
- B. Circle the appropriate descriptor (**strongly supports** | **supports** | **contradicts** | **has nothing to do with**).
- C. Write the letter of the model you are writing about.
- D. Then write your reason.

**1. Evidence # \_\_\_\_ strongly supports | supports | contradicts | has nothing to do with Model \_\_\_\_ because:**

**2. Evidence # \_\_\_\_ strongly supports | supports | contradicts | has nothing to do with Model \_\_\_\_ because:**

**3. Evidence # \_\_\_\_ strongly supports | supports | contradicts | has nothing to do with Model \_\_\_\_ because:**

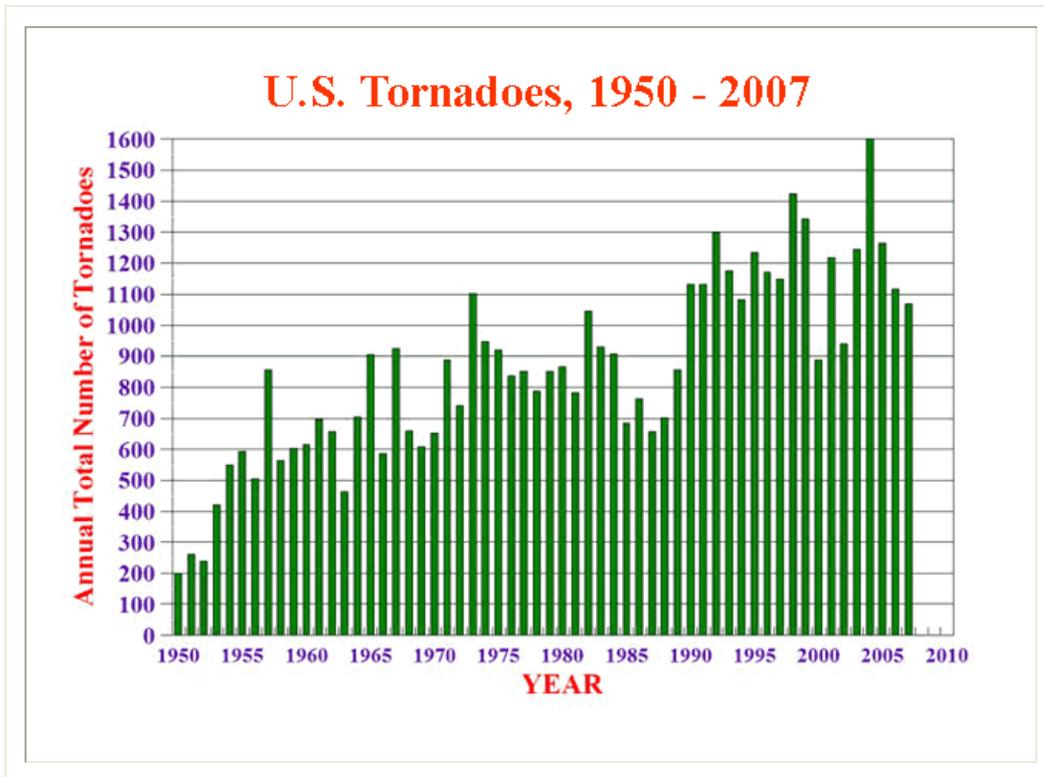
**4. Circle the plausibility of each model. [Make two circles. One for each model.]**

	Greatly implausible (or even impossible)										Highly Plausible
<b>Model A</b>	1	2	3	4	5	6	7	8	9	10	
<b>Model B</b>	1	2	3	4	5	6	7	8	9	10	

**5. Circle the model which you think is correct. [Only circle one choice below.]**

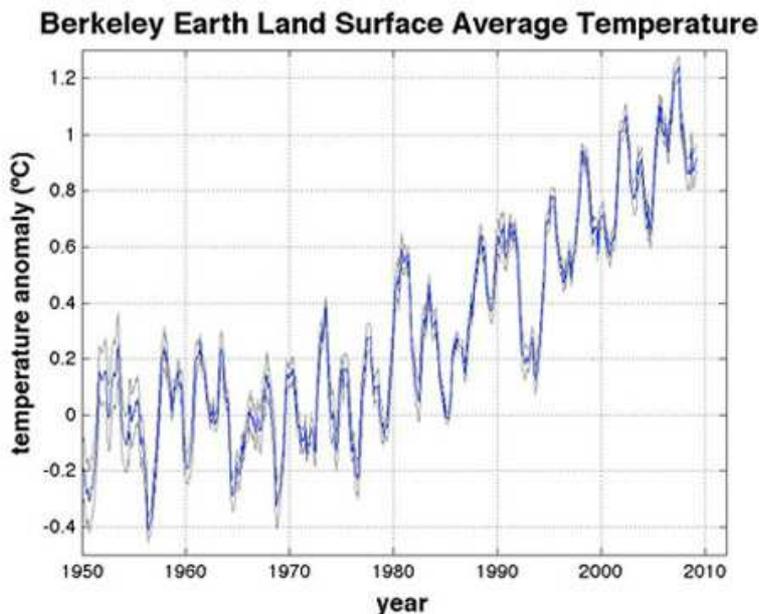
Very certain that Model A is correct	Somewhat certain that Model A is correct	Uncertain if Model A or B is correct	Somewhat certain that Model B is correct	Very certain that Model B is correct
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**Evidence #1: The annual number of tornadoes has been increasing in the United States for the past 50 years. During this time period, Earth's average surface temperature has been increasing as well. FIGURE #1**



This graph shows the number of tornadoes reported in the U.S. since 1950. The annual number of tornadoes have been increasing.

**FIGURE # 2**



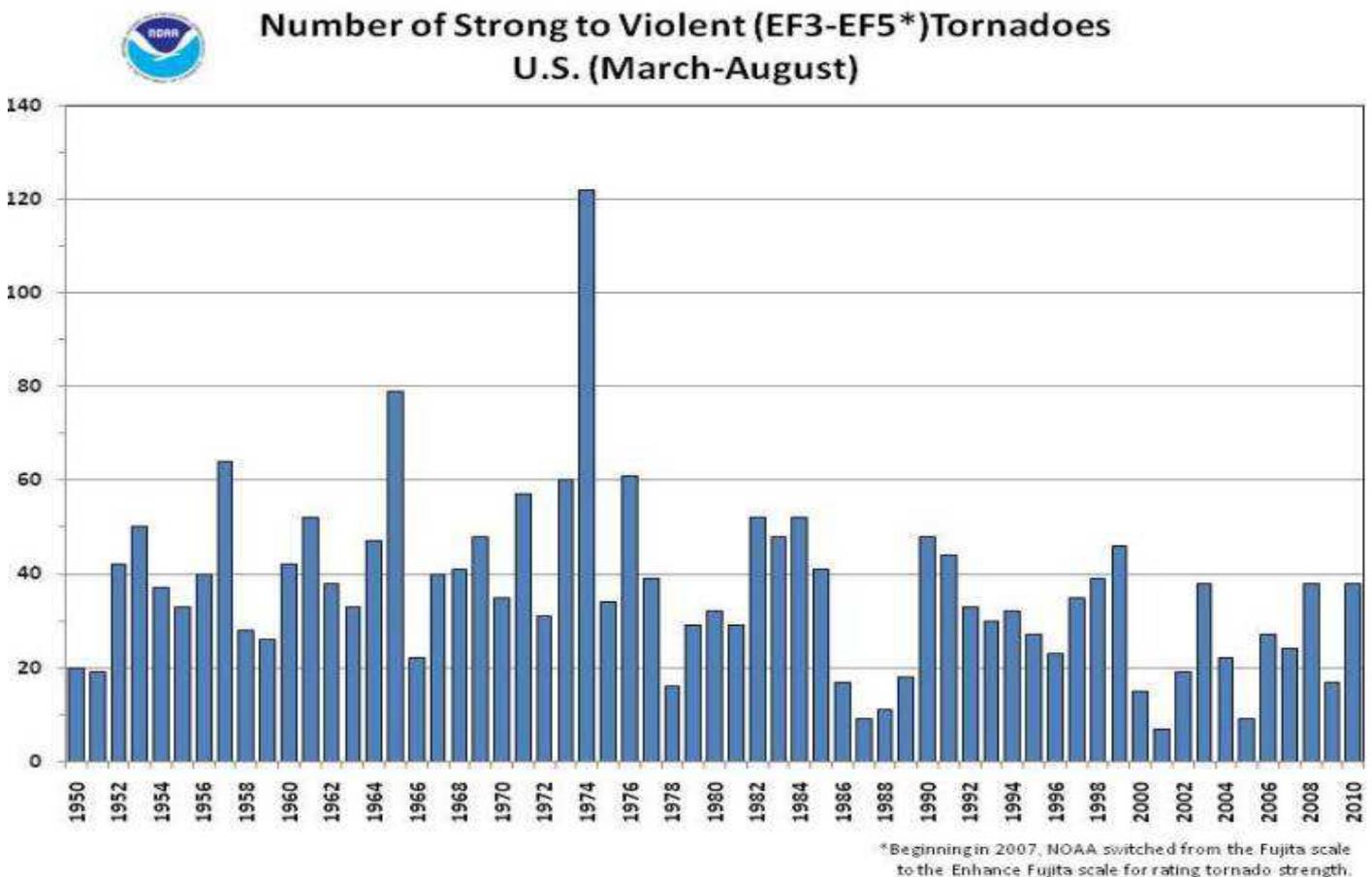
This graph shows the average surface temperature of the Earth since 1950. The temperature anomaly along the Y-axis means how much the average yearly temperature increased or decreased from the mean. Earth's surface temperature has been increasing.

Source: <http://www.wunderground.com/climate/extreme.asp>

**Evidence #2: An increase in Doppler radar coverage and greater attention to reporting tornadoes has caused an increase in tornado records.**

Today, nearly all of the United States is reasonably well covered by NOAA's Doppler weather radars. Even if a tornado is not actually observed, modern damage assessments (includes Doppler radar data) by National Weather Service personnel can discern if a tornado caused the damage, and if so, how strong the tornado may have been. This gap between tornado records of the past and current records contributes a great deal of uncertainty regarding questions about the long-term behavior or patterns of tornado occurrence. In addition, even today many smaller tornadoes still may go undocumented in places with low populations or inconsistent communication facilities.

With increased national Doppler radar coverage and greater attention to tornado reporting, there has been an increase in the number of tornado reports over the past several decades. This can create a misleading appearance of an increasing trend in tornado frequency. To better understand the true variability and trend in tornado frequency in the US, the total number of strong to violent tornadoes (EF3 to EF5 category on the Enhanced Fujita scale) can be analyzed. These are the tornadoes that would have likely been reported even during the decades before Doppler radar use became widespread and practices resulted in increasing tornado reports. The bar chart below indicates there has been little trend in the frequency of the strongest tornadoes over the past 55 years.

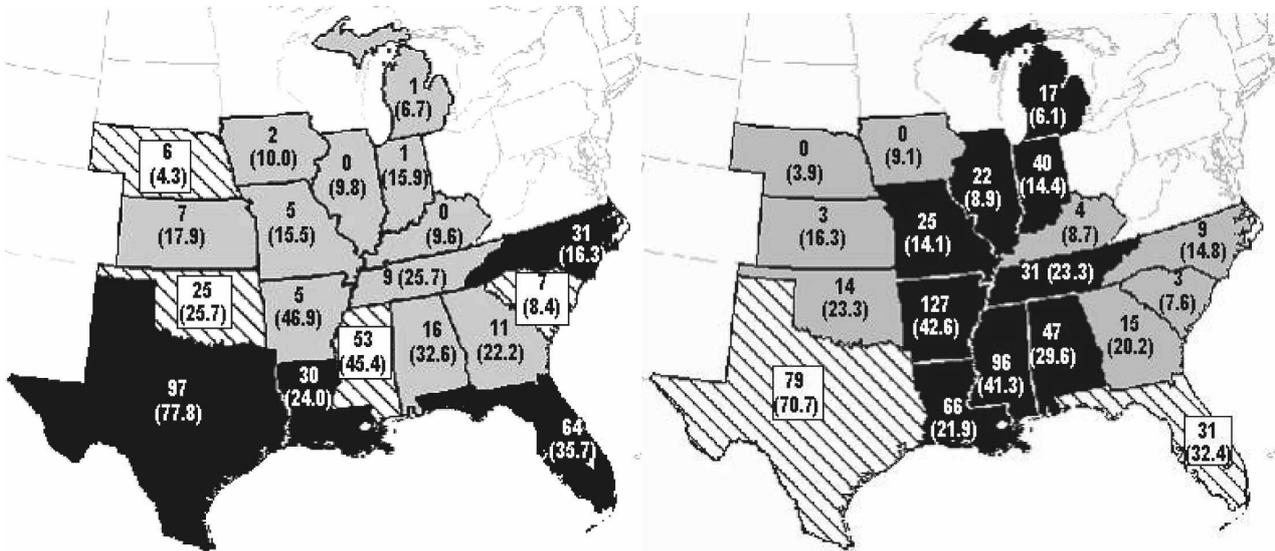


Source: <http://www.ncdc.noaa.gov/oa/climate/severeweather/tornadoes.html>

**Evidence #3: Tornado outbreaks in the United States are stronger and more frequent after winter periods of cooler Pacific sea surface temperatures (La Nina).**

Winter tornado activity (January–March) between 1950 and 2003 was analyzed to determine the possible effect of seasonally averaged sea surface temperatures in the Pacific Ocean, on the location and strength of tornado outbreaks in the United States. Tornado activity was gauged through analyses of tornadoes occurring on tornado days (a calendar day featuring six or more tornadoes within the contiguous United States) and strong and violent tornado days (a calendar day featuring five or more tornadoes rated F2 and greater within the contiguous United States).

It is seen that during winter periods of La Nina with anomalously cool Pacific sea surface temperatures, there is a tendency for U.S. tornado outbreaks to be stronger and more frequent than they are during winter periods of anomalously warm tropical Pacific sea surface temperatures (El Niño). See chart below.



**Left U.S. Map: Tornadoes occurring during El Niño winters by state.**

**Right U.S. Map: Tornadoes occurring during La Niña winters by state.**

Numbers in parentheses are the expected number of tornadoes.

States outlined in black experienced greater than 125% of the expected number of tornadoes

States outlined in gray experienced less than 75% of their expected value.

States outlined in the stripes experienced within 25% of the expected value of tornadoes.

Source: <http://www.spc.noaa.gov/publications/cook/enso-mwr.pdf>

**Evidence #4: The Mid-West populations of the United States have increased significantly in the past 100 years.**

One of the main difficulties with tornado records is that a tornado or evidence of a tornado must have been observed. Unlike rainfall or temperature, which may be measured by a fixed instrument, tornadoes are ephemeral and very unpredictable. If a tornado occurs in a place with few or no people, it is not likely to be documented. Unfortunately, much of what we know as tornado alley was very sparsely populated until the 20th century, and so it is possible that many significant tornadoes may never have made it into the historical record.

Total Mid-West (States in Tornado Alley) Population since 1990, according to the U.S. Census.

<b>Year</b>	<b>Total Population</b>
1900	26,333,004
1910	29,888,542
1920	34,019,792
1930	38,594,100
1940	40,143,332
1950	44,460,762
1960	51,619,139
1970	56,590,294
1980	58,866,998
1990	58,866,998
2000	64,392,776

Source(s): <http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf>  
<http://www.ncdc.noaa.gov/oa/climate/severeweather/tornadoes.html>