

# **Tornado Warnings: Past, Present, and Future**

**Patrick T. Marsh  
(@pmarshwx)**

PhD. Candidate

Liaison to the Hazardous Weather Testbed

NOAA/OAR National Severe Storms Laboratory

OU Cooperative Institute for Mesoscale Meteorological Studies

OU School of Meteorology

[patrick.marsh@noaa.gov](mailto:patrick.marsh@noaa.gov)

# What Motivated This?

- On 14 April 2011, Fort Smith, AR was placed under a Tornado Warning as a cyclic supercell with a history of producing tornadoes approached the city
- Fort Smith Police Department did **NOT** sound the sirens
- Community Storm Shelters are keyed to unlock based on siren tones
- Many people were “locked out” of shelter for the duration of the Tornado Warning.

**Although failing to sound the sirens was bad, what really got me thinking about this issue was the response from the Fort Smith Police Chief**

# What Motivated This?

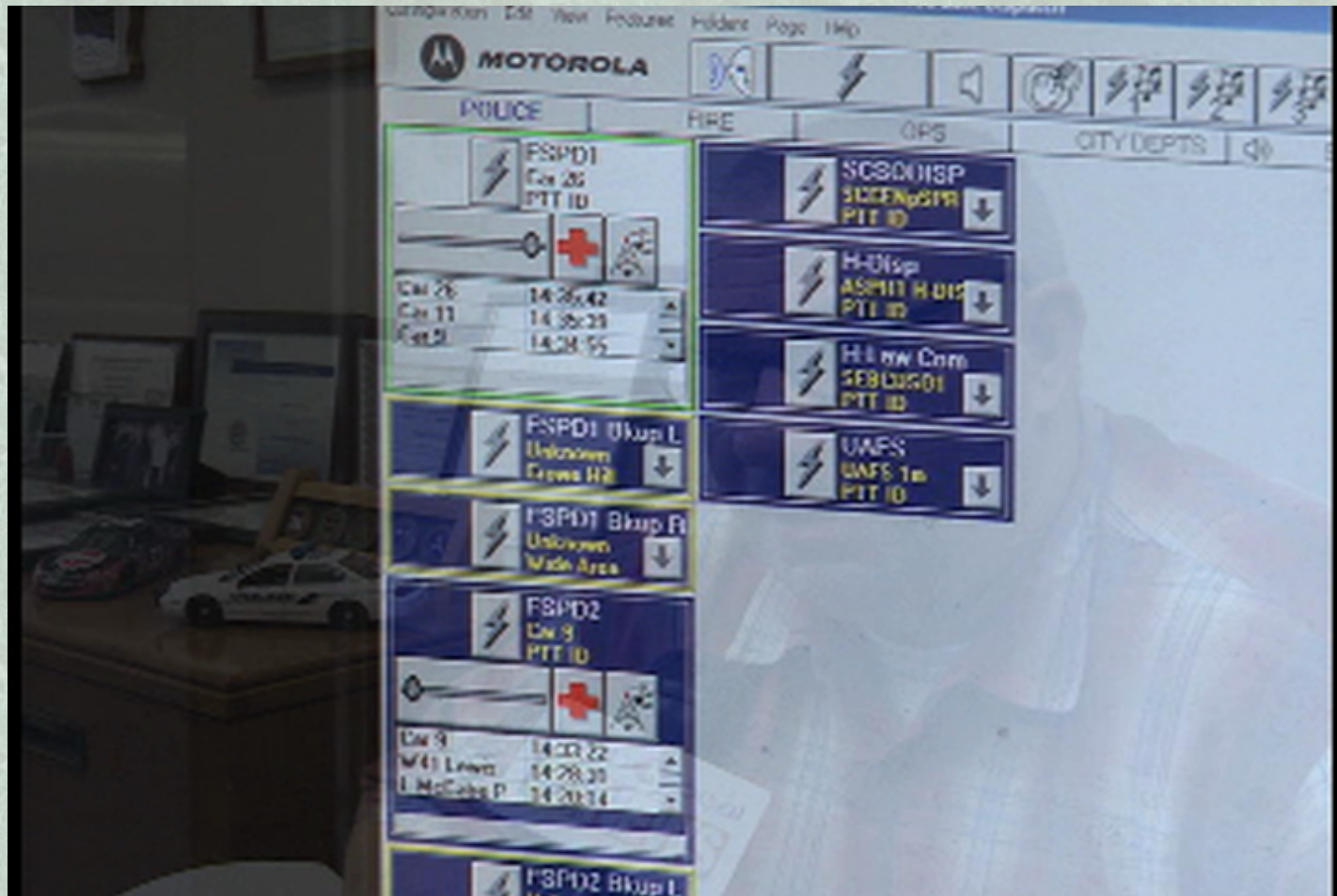


\*Video Courtesy of KFSM in Fort Smith, AR



**That's promising, after all,  
community residents need the  
sirens to unlock the shelters.**

# What Motivated This?

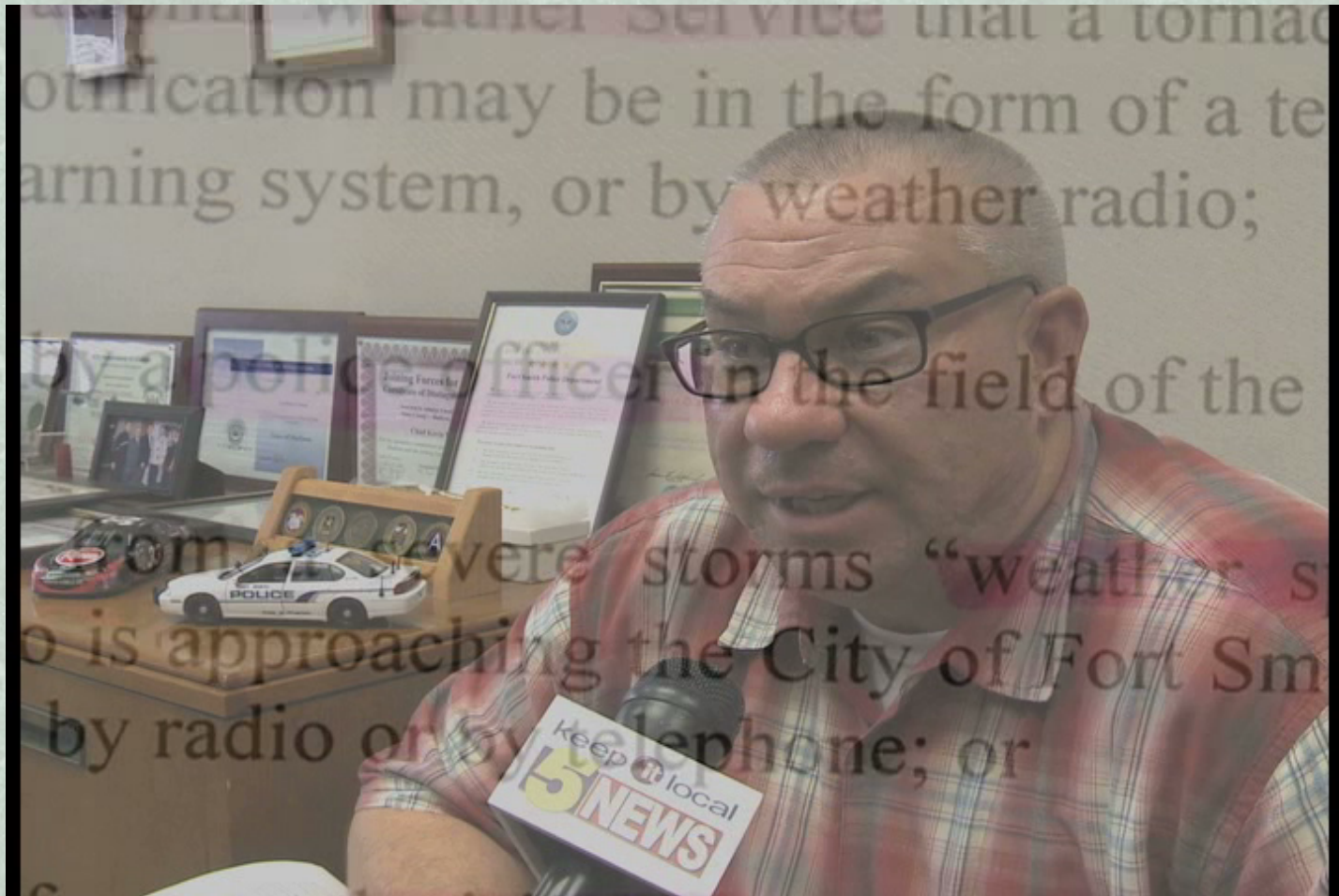


\*Video Courtesy of KFSM in Fort Smith, AR

**Wait? Whose judgment are residents trusting? Yours or the National Weather Service's?**



# What Motivated This?



\*Video Courtesy of KFSM in Fort Smith, AR



**But the NWS had issued a  
Tornado Warning!**

# What Motivated This?



\*Video Courtesy of KFSM in Fort Smith, AR

**So residents have to wait for the  
tornado before they can take  
shelter? Why is that?**



# What Motivated This?



\*Video Courtesy of KFSM in Fort Smith, AR



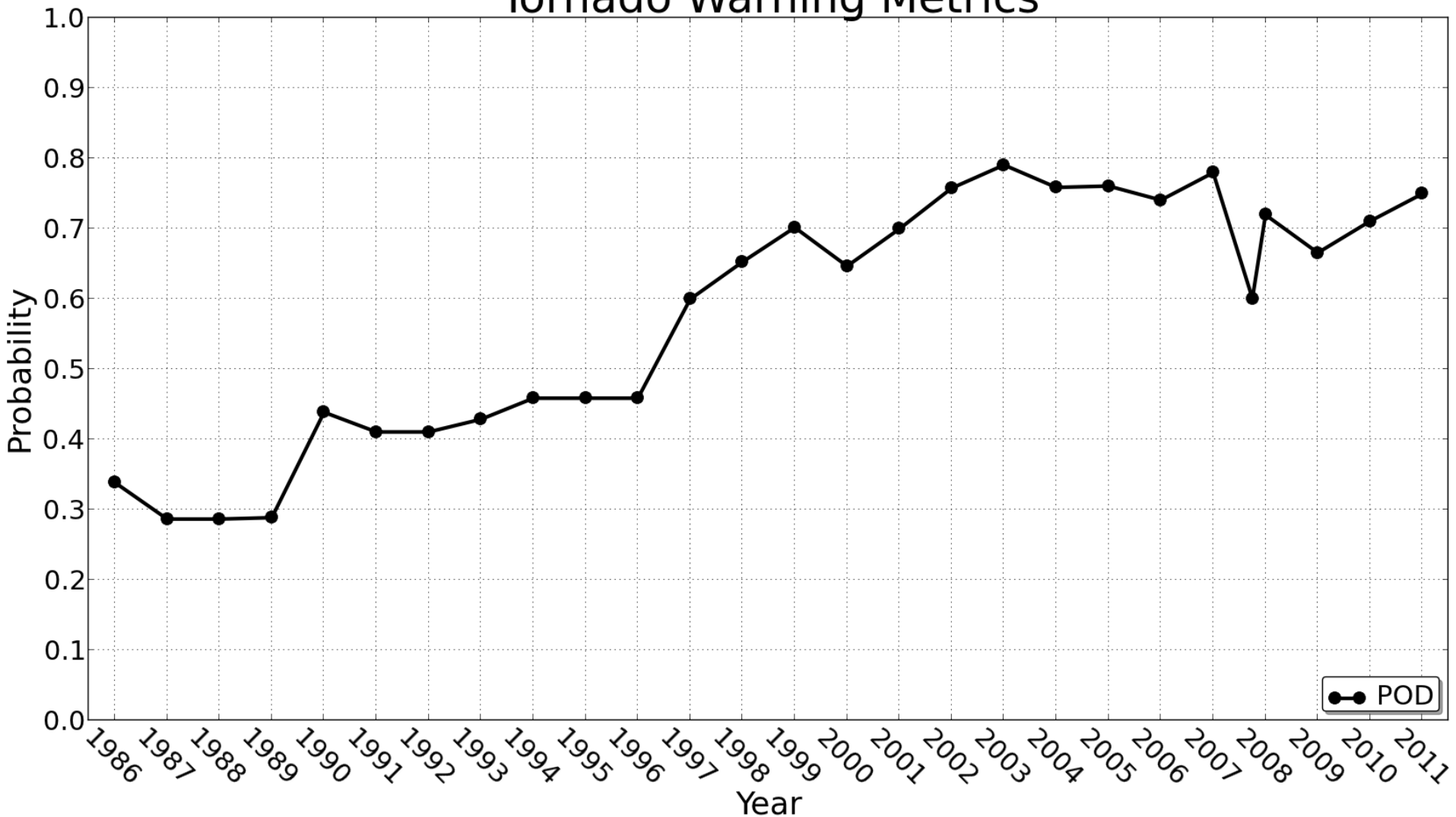
# **The Complacency Argument**

**Similar stories can be inferred from  
watching TV coverage of the 27-28  
April 2011 Tornado Outbreak.**

**Why is there a complacency issue?**

# Probability of Detection

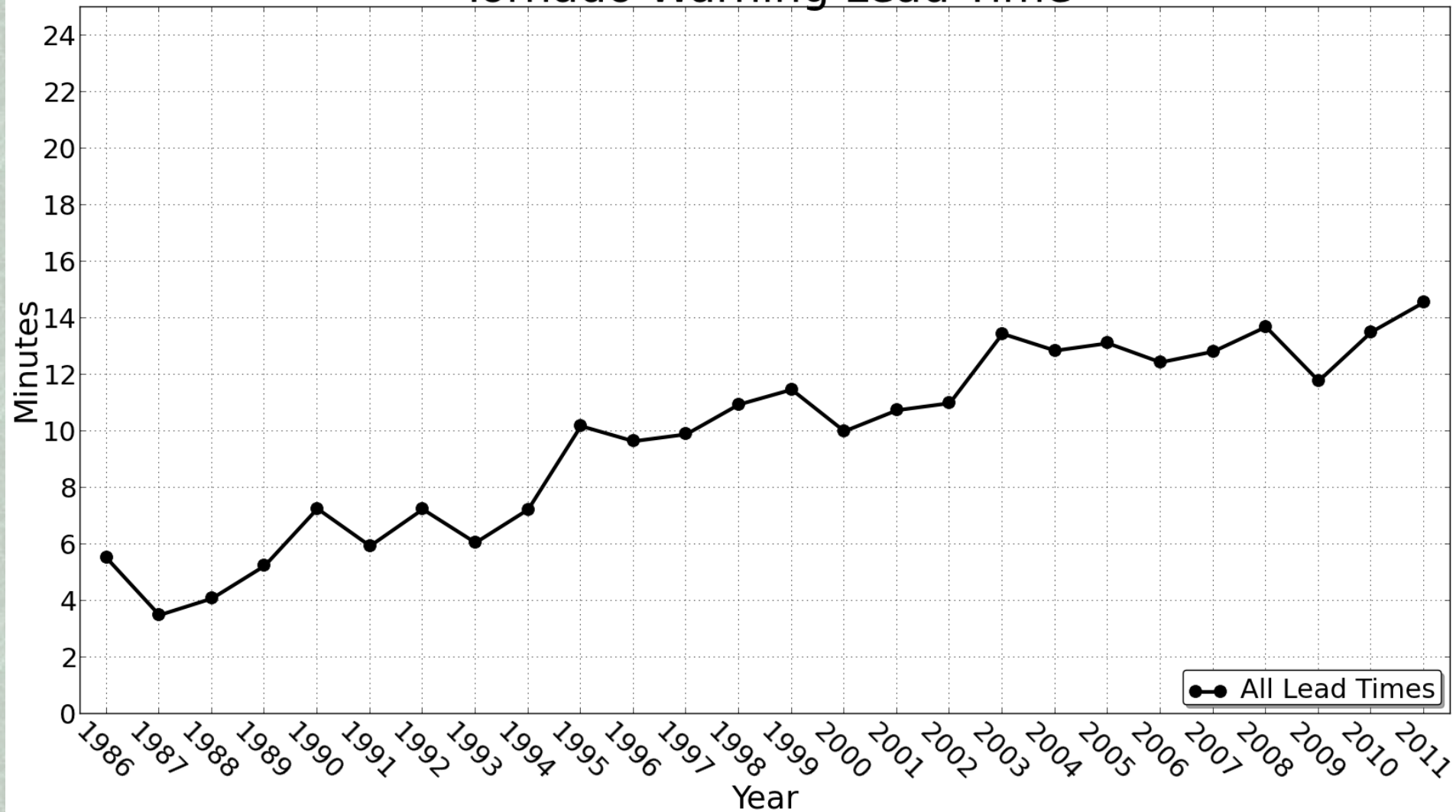
## Tornado Warning Metrics



\*Data from the NWS Performance Branch

# Lead Time

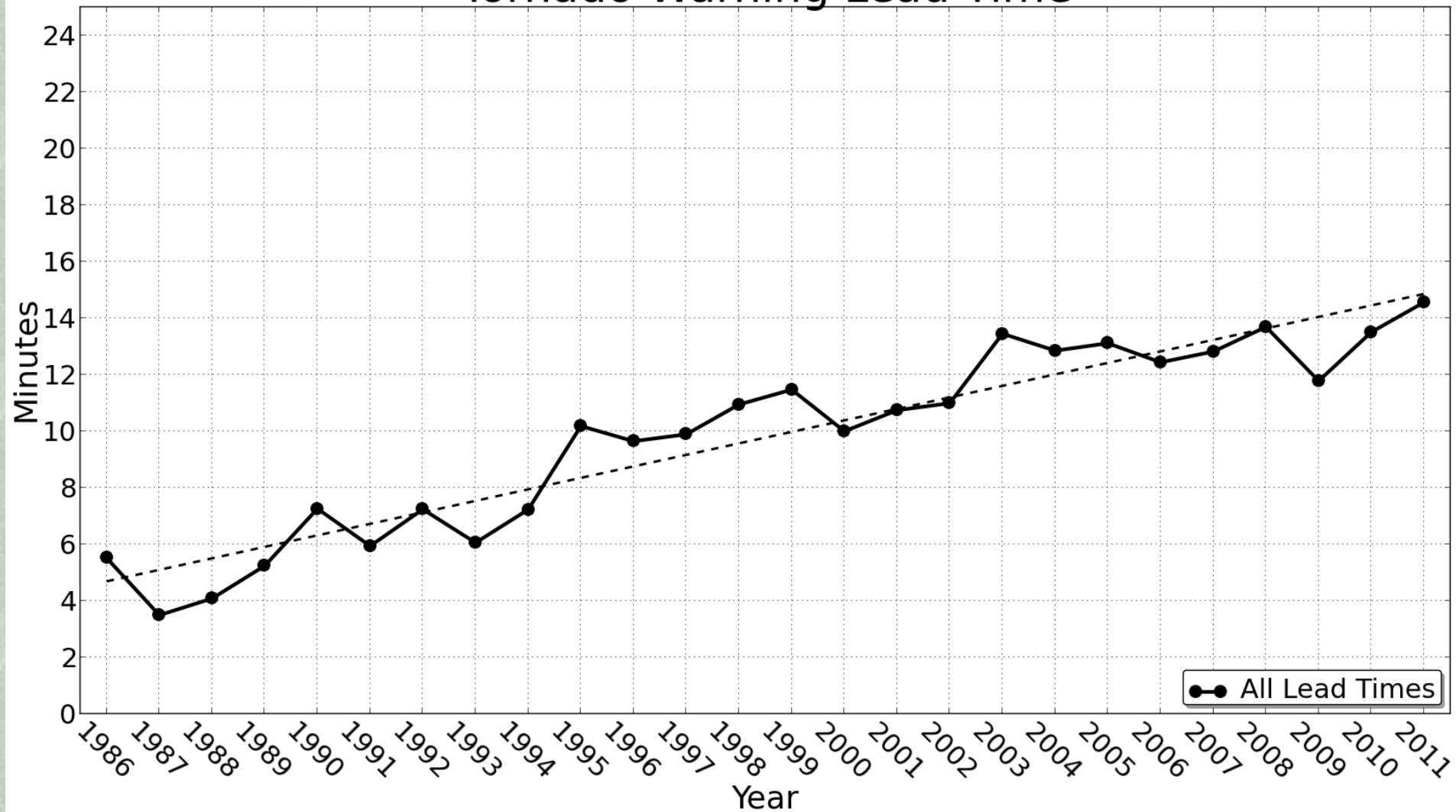
## Tornado Warning Lead Time



\*Data from the NWS Performance Branch

# Lead Time

## Tornado Warning Lead Time

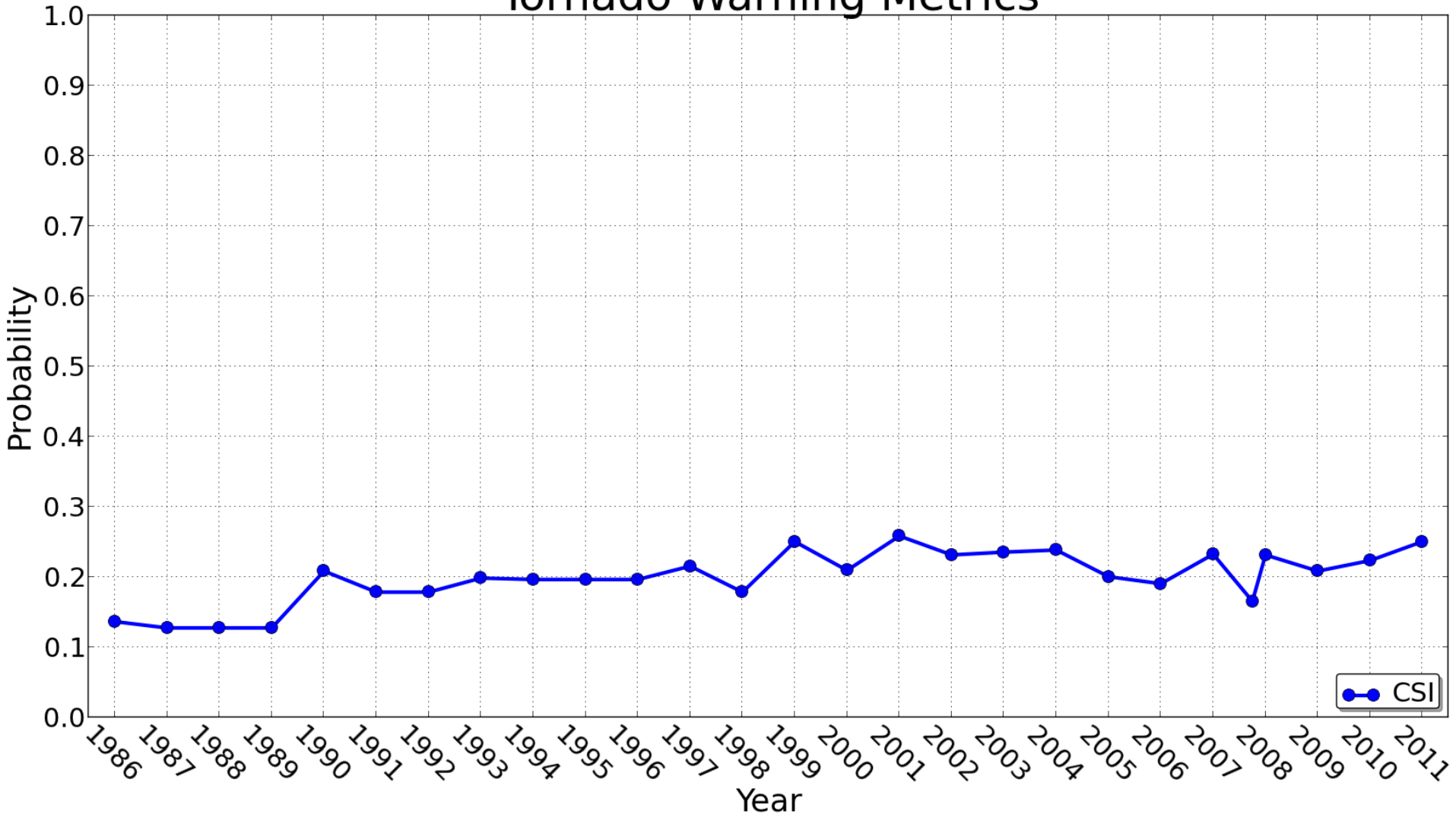


\*Data from the NWS Performance Branch



# Critical Success Index

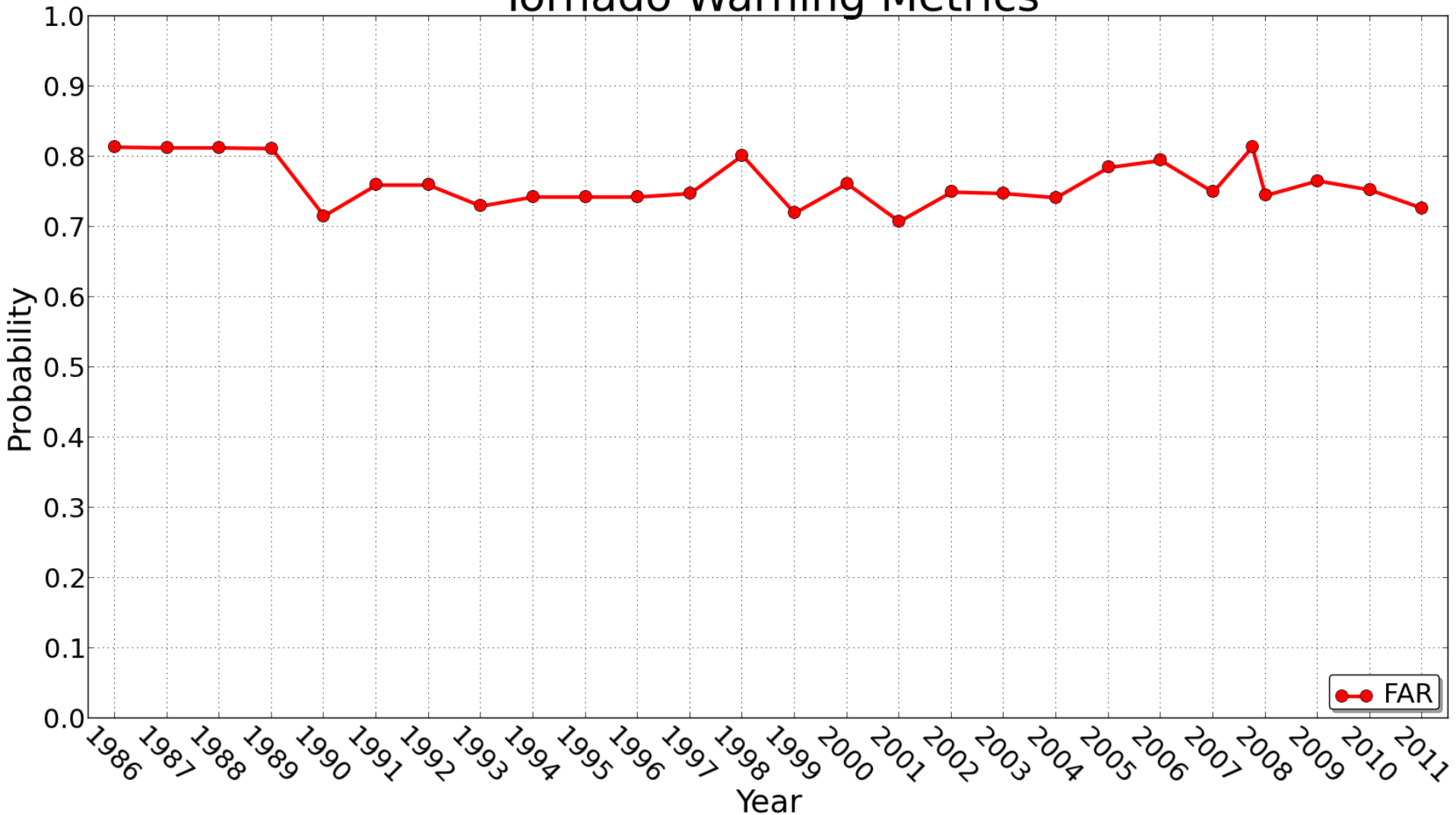
## Tornado Warning Metrics



\*Data from the NWS Performance Branch

# False Alarm Ratio

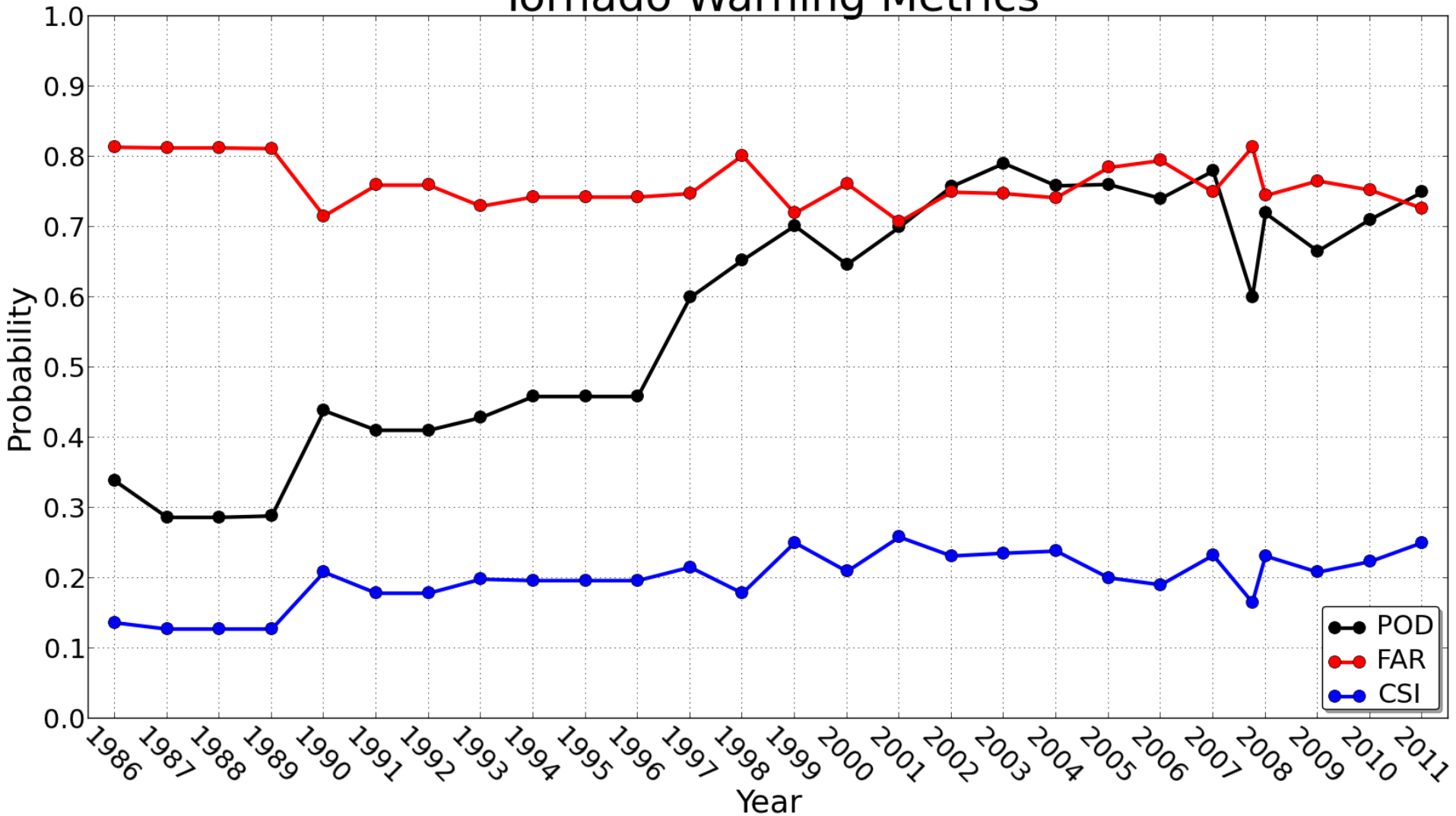
## Tornado Warning Metrics



\*Data from the NWS Performance Branch

# POD, FAR, CSI

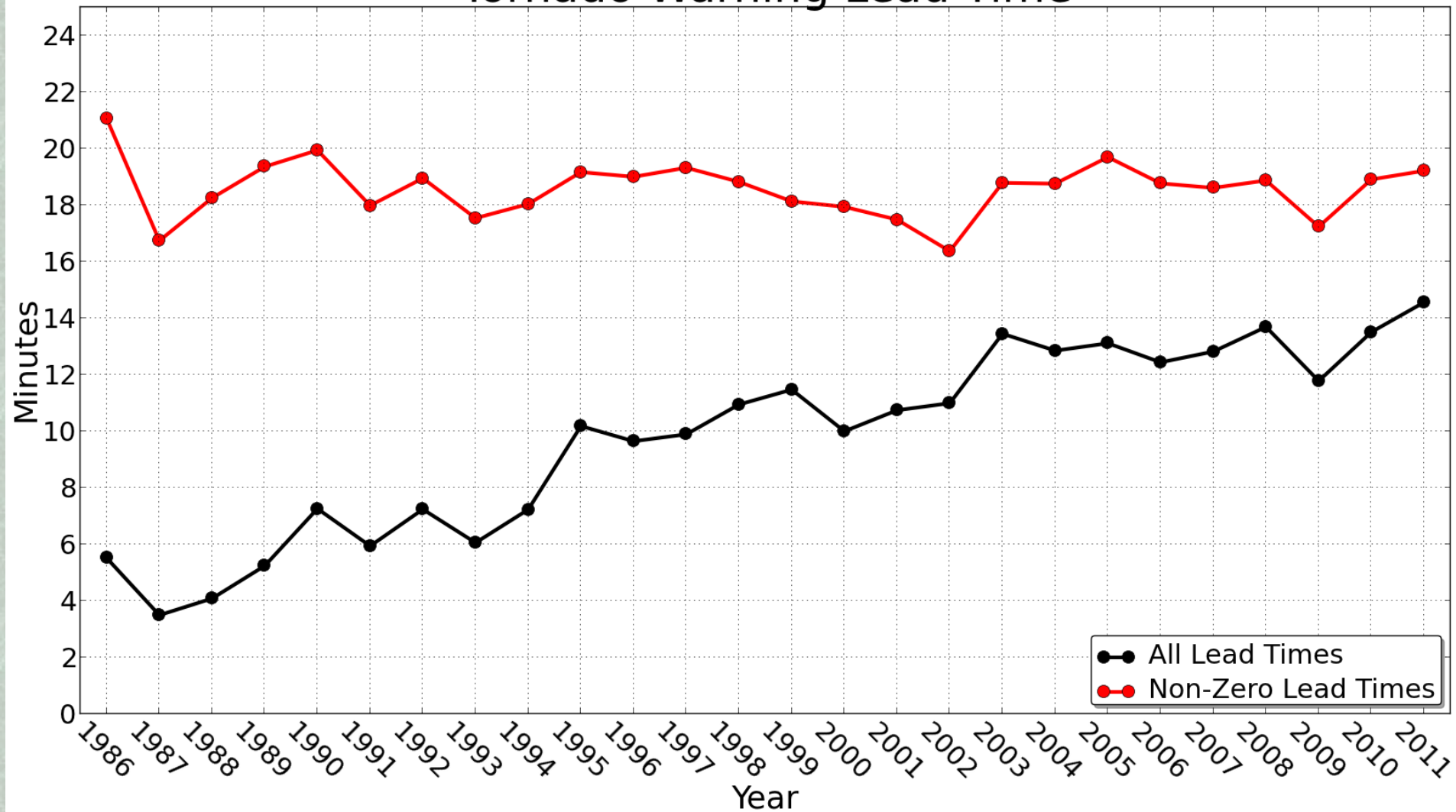
## Tornado Warning Metrics



\*Data from the NWS Performance Branch

# Revisiting Lead Time

## Tornado Warning Lead Time

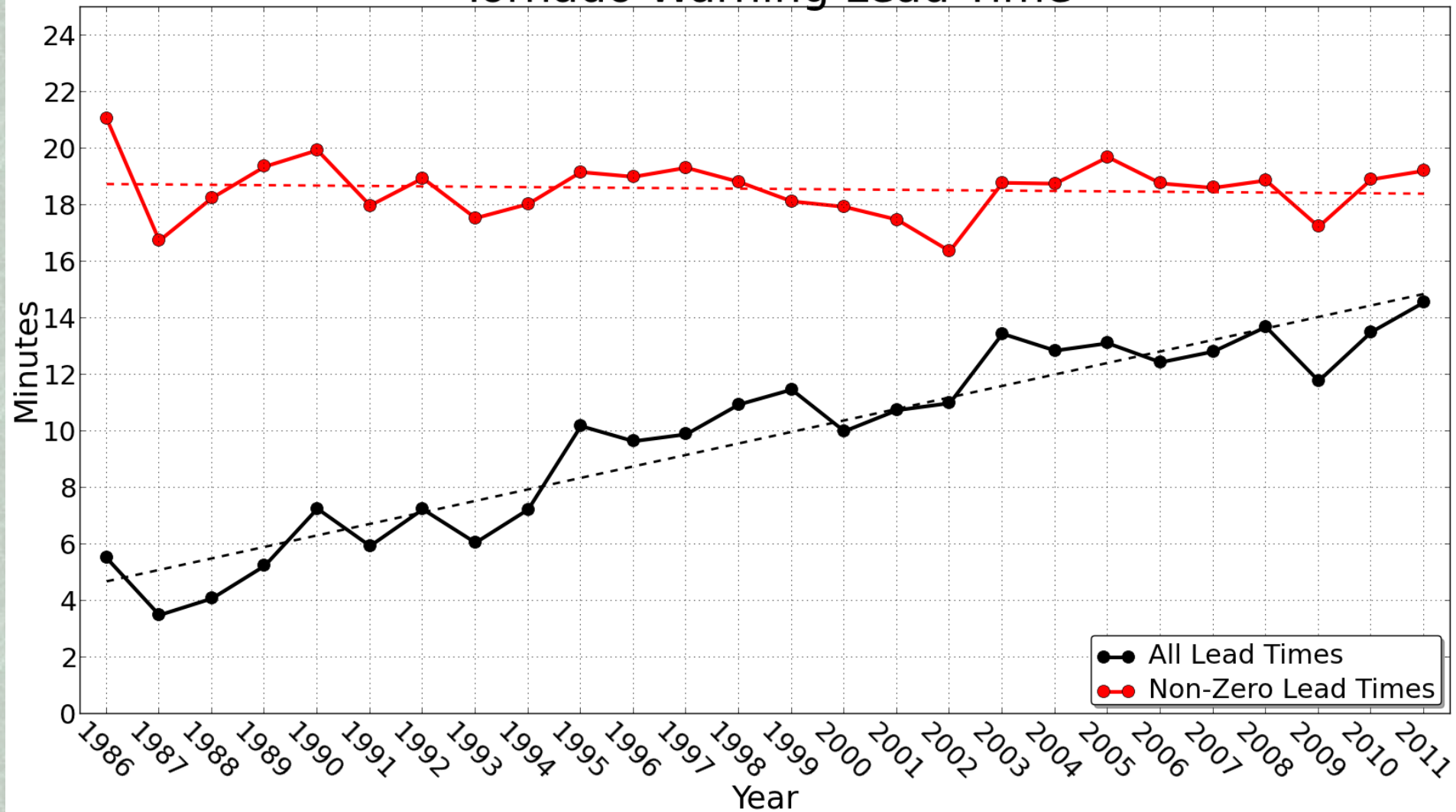


\*Data from the NWS Performance Branch



# Revisiting Lead Time

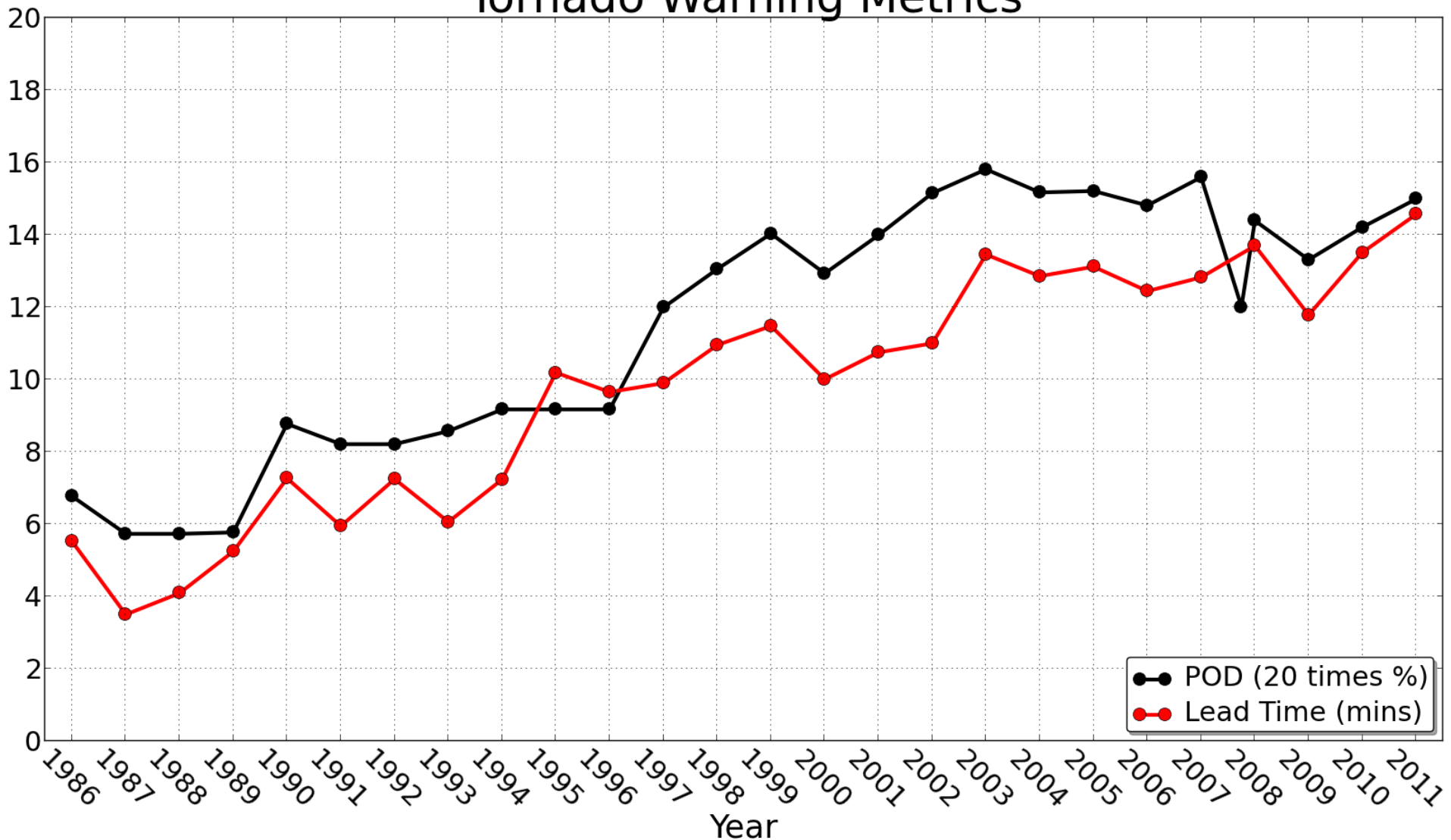
## Tornado Warning Lead Time



\*Data from the NWS Performance Branch

# Revisiting Lead Time

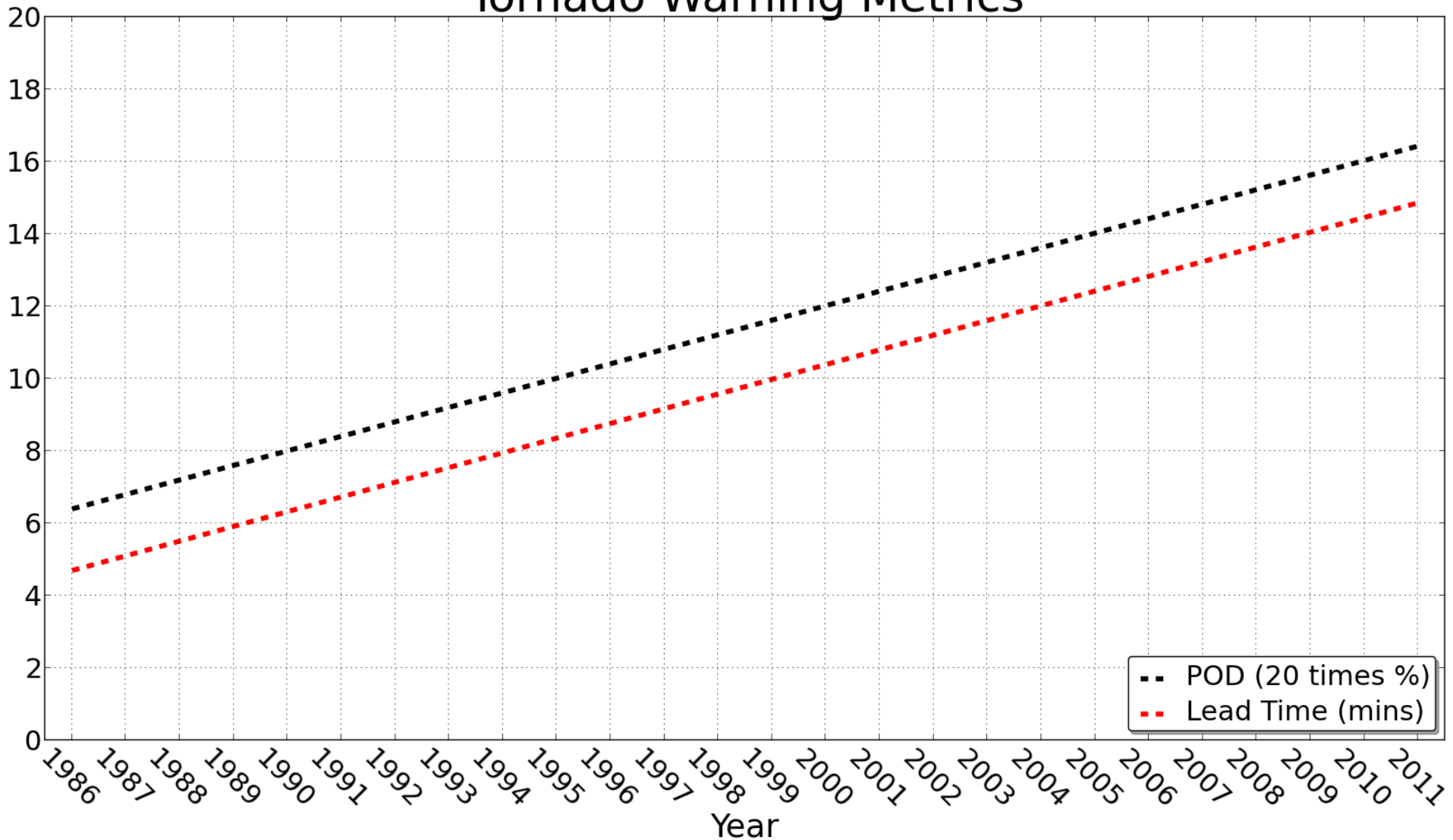
## Tornado Warning Metrics



\*Data from the NWS Performance Branch

# Revisiting Lead Time

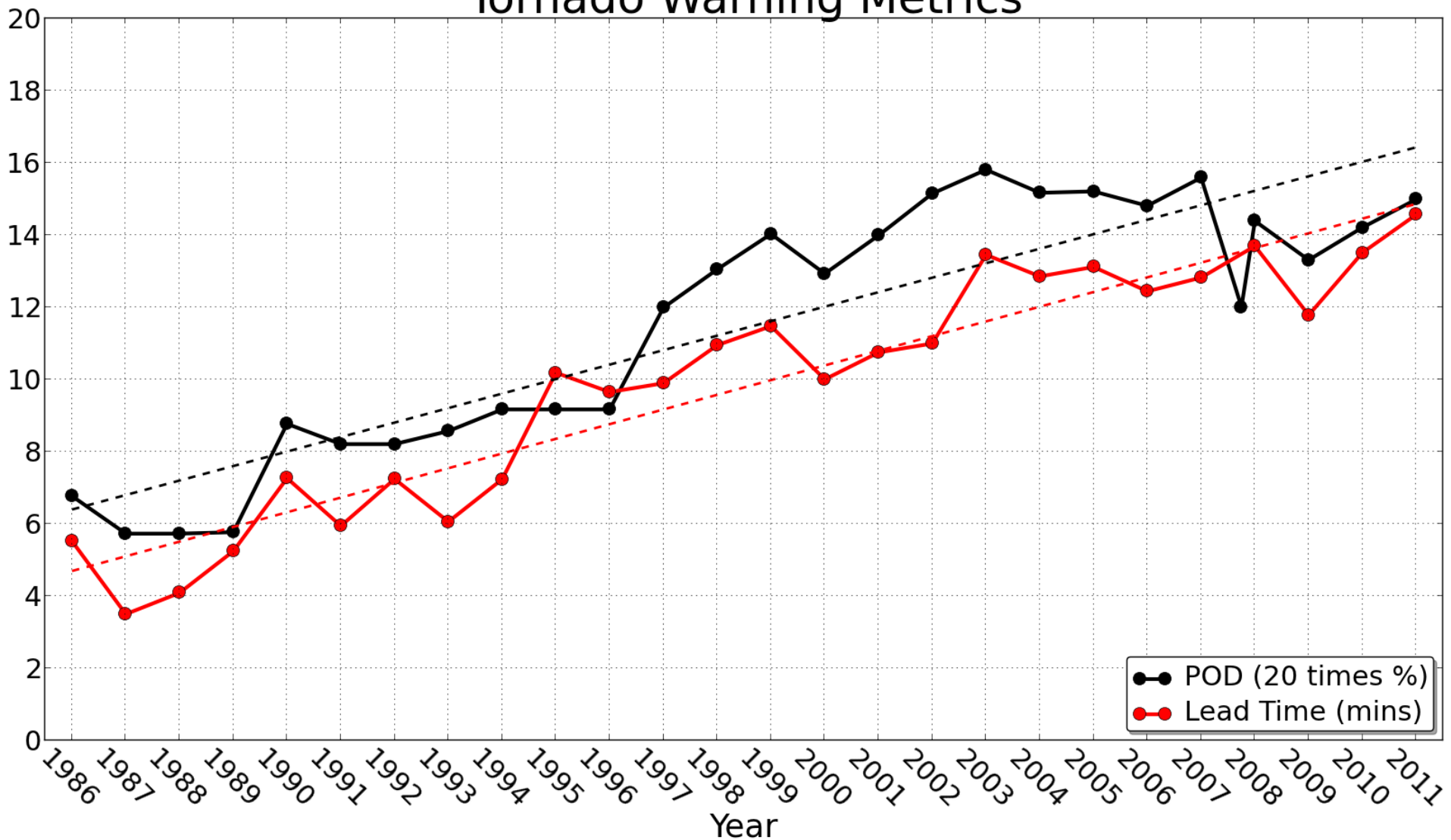
## Tornado Warning Metrics



\*Data from the NWS Performance Branch

# Revisiting Lead Time

## Tornado Warning Metrics

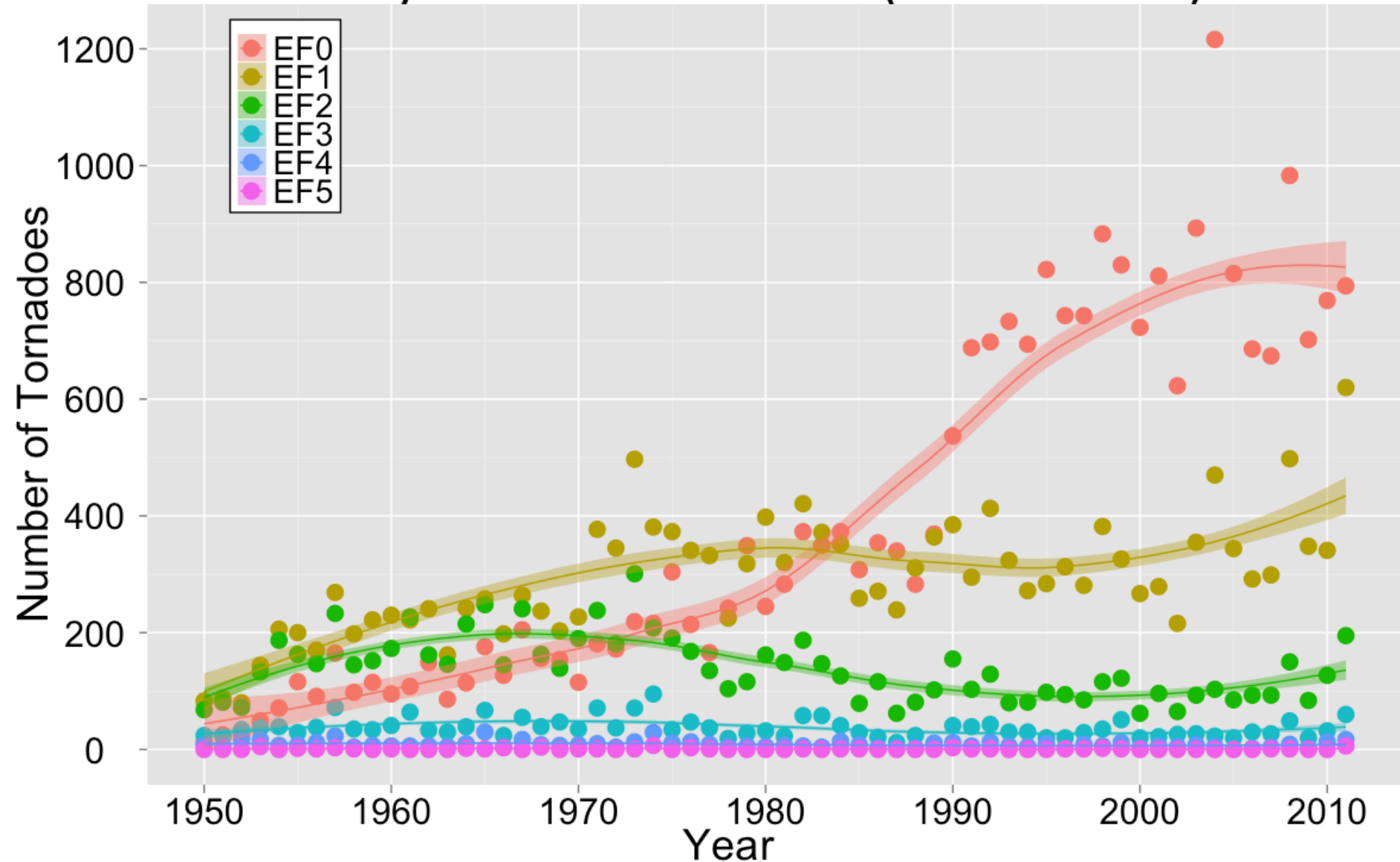


\*Data from the NWS Performance Branch

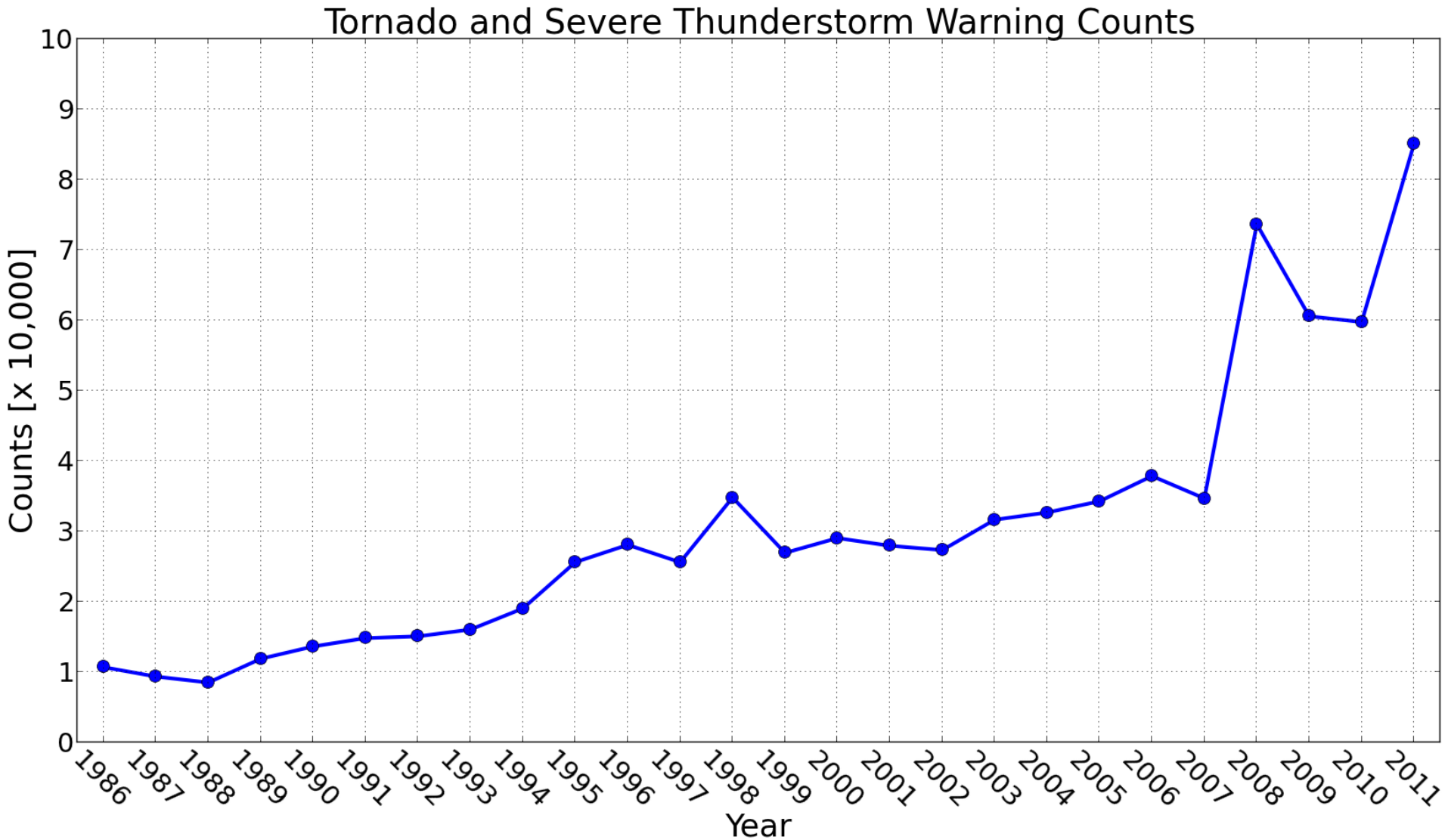


# Should People Be Complacent?

## Yearly Tornado Counts (1950-2011)

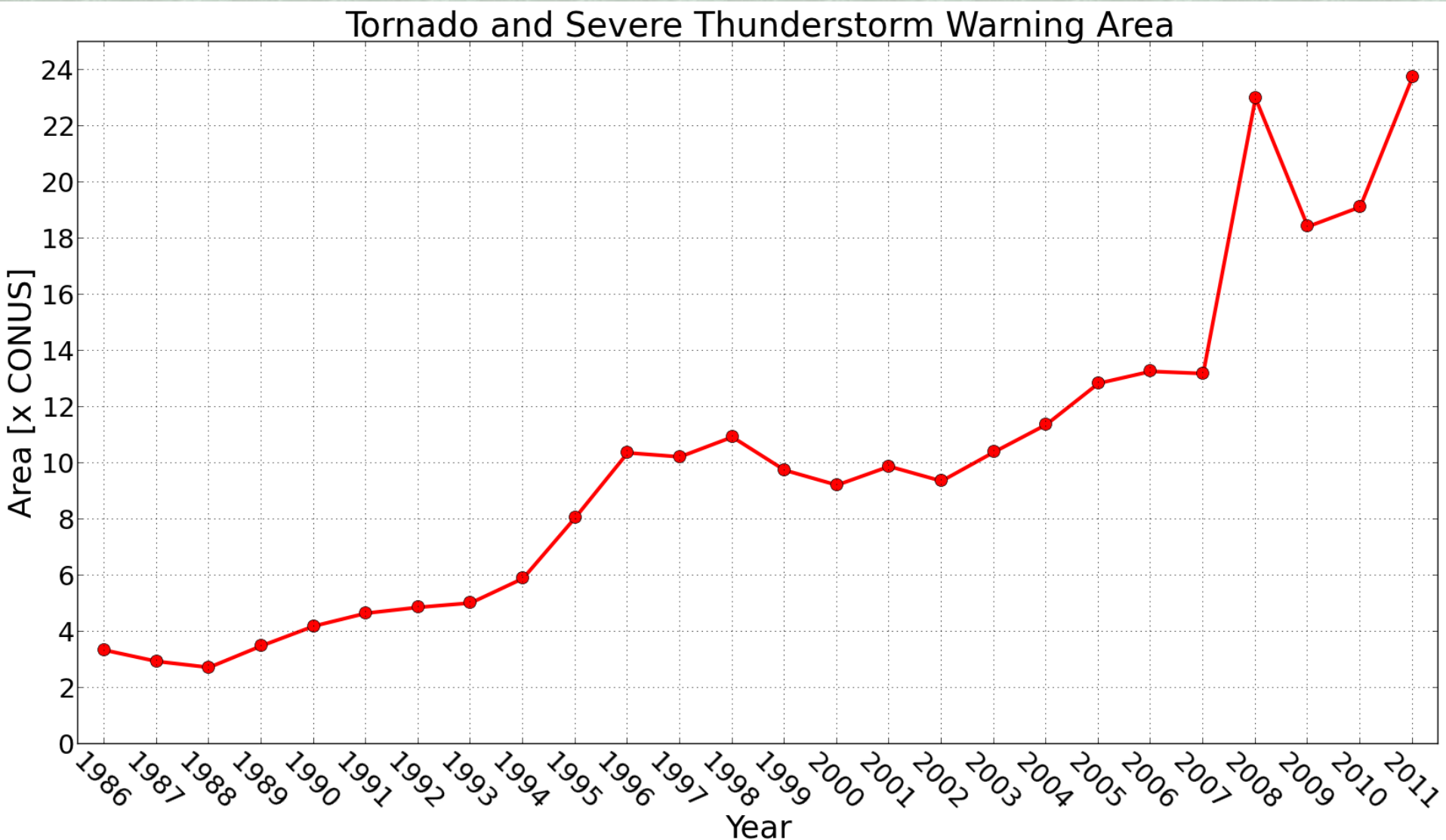


# Total Warning (SVR+TOR) Counts



\*Numbers provided by Daryl Herzmann

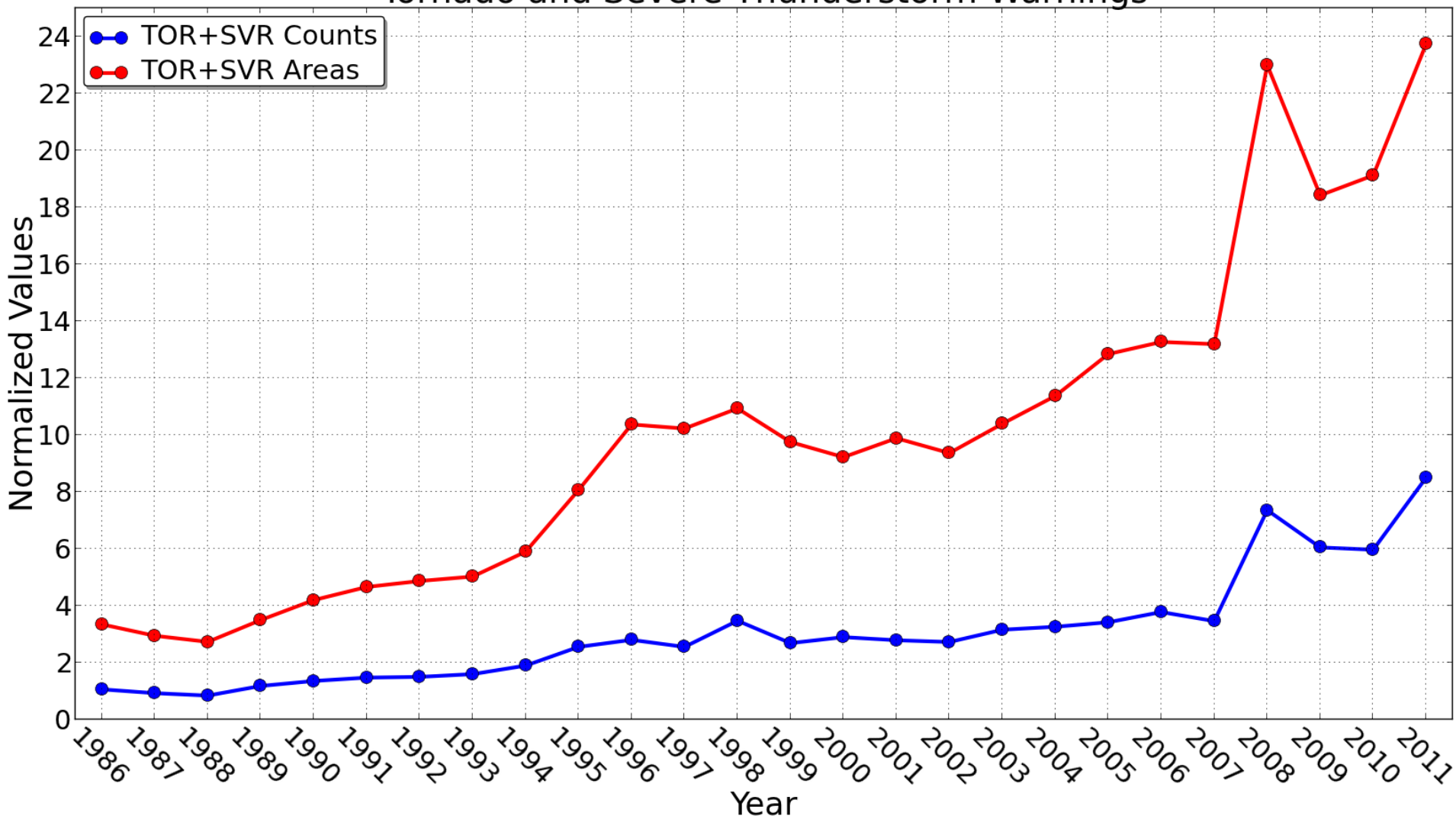
# Total Warning (SVR+TOR) Area



\*Numbers provided by Daryl Herzmann

# Total Warning (SVR+TOR)

Tornado and Severe Thunderstorm Warnings

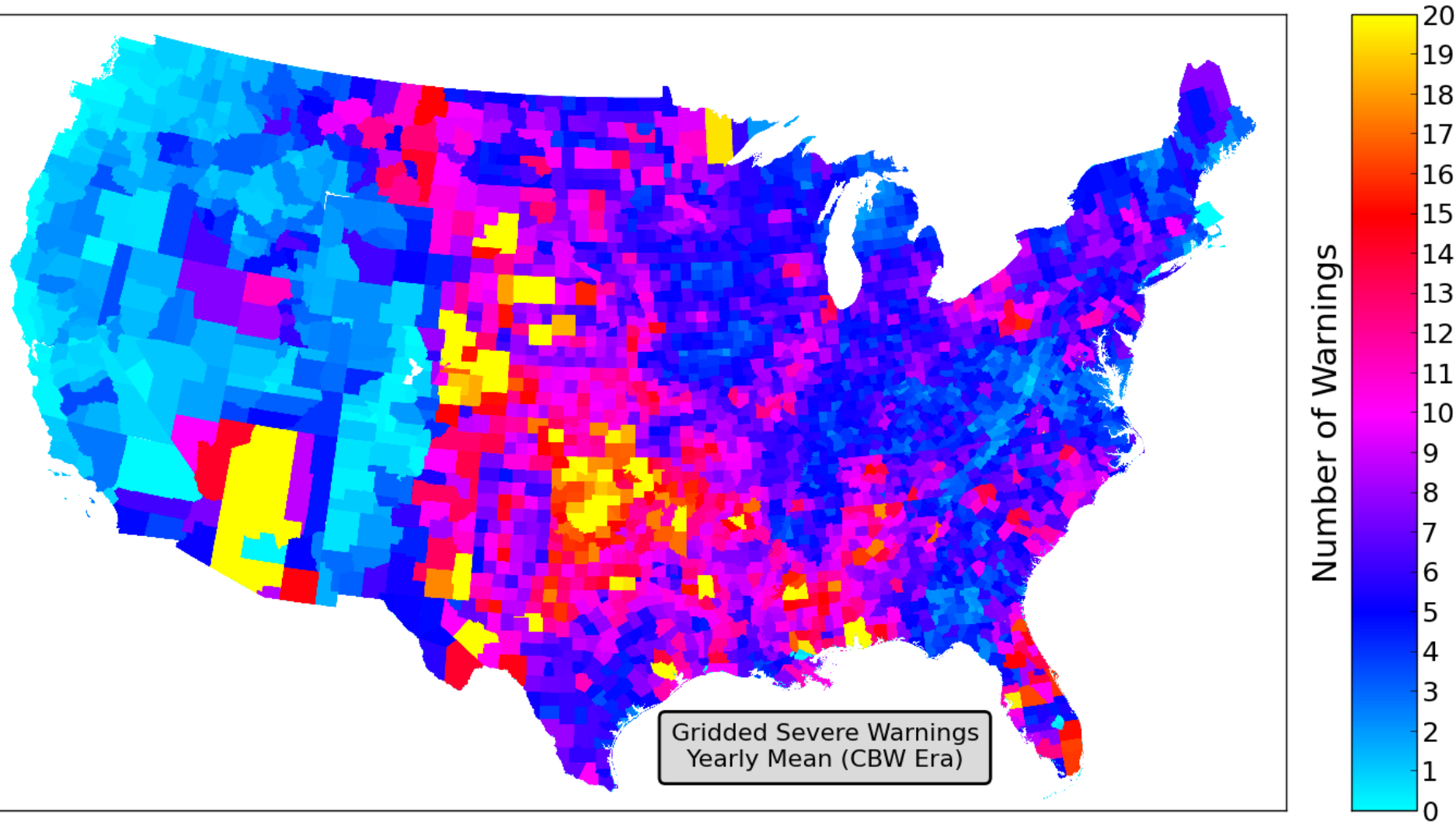


\*Numbers provided by Daryl Herzmann



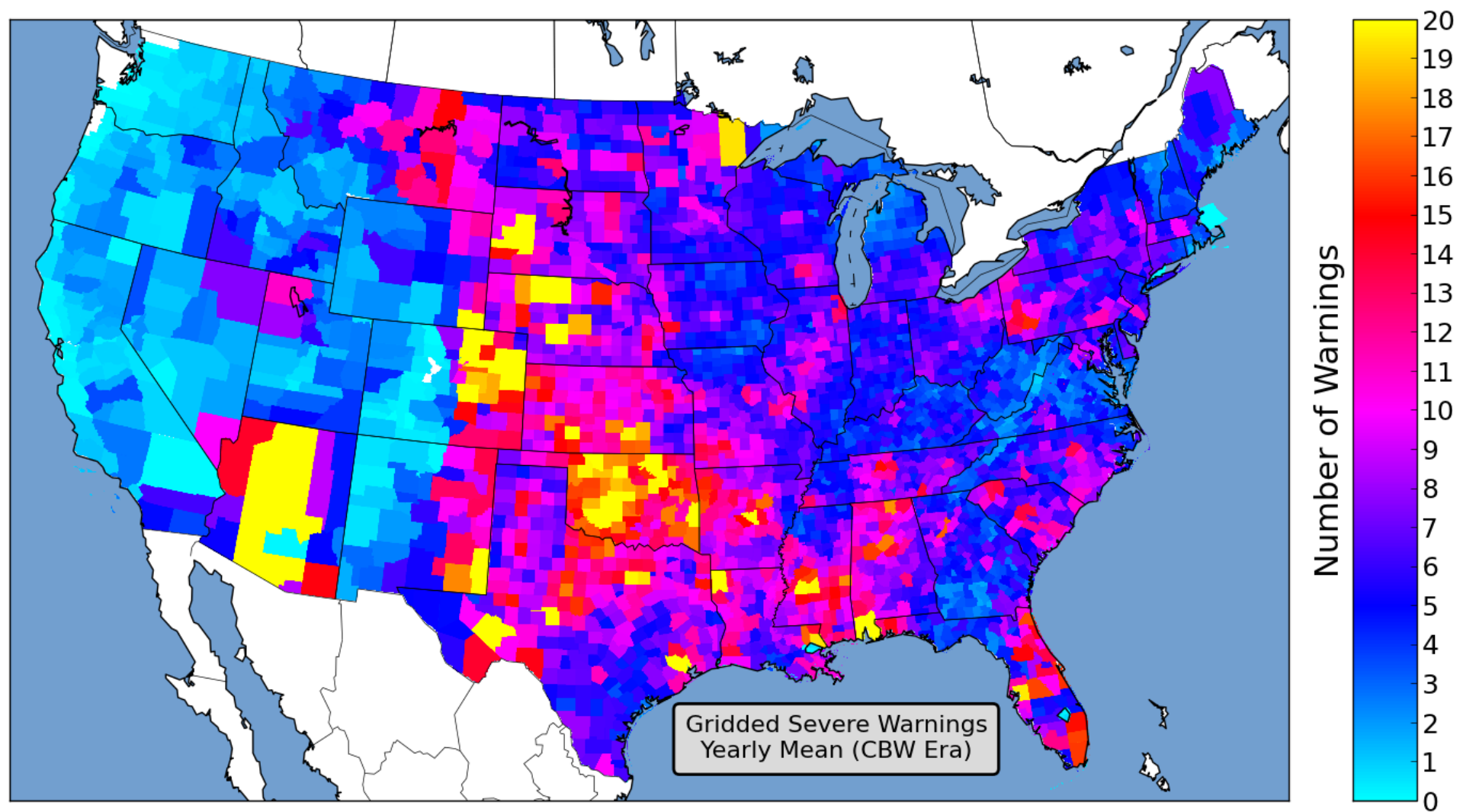
# **The Actual Warnings...**

# Yearly Mean Severe Warnings – CBW Era



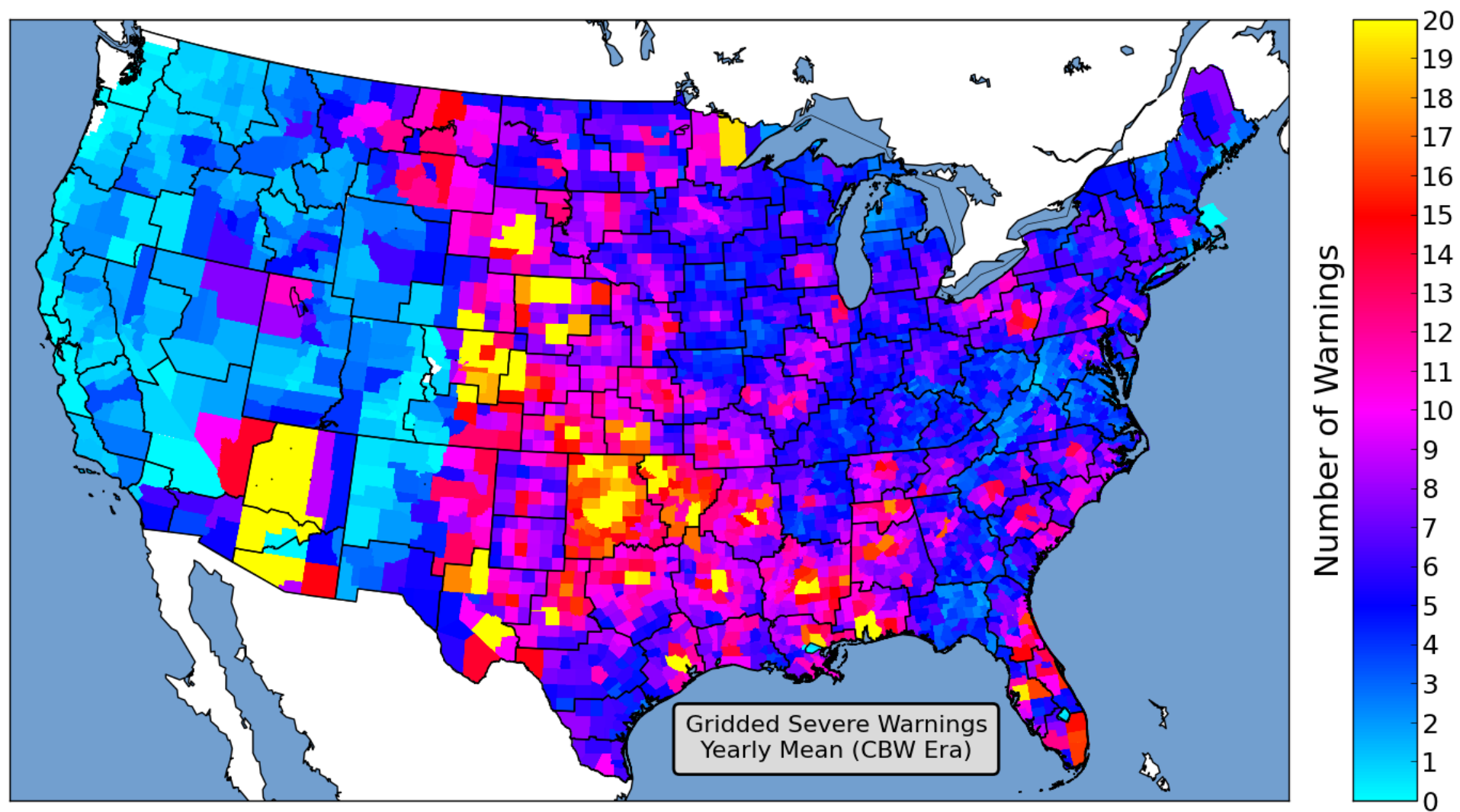
**CBW = 01 January 1986 – 30 September 2007**

# Yearly Mean Severe Warnings – CBW Era



**CBW = 01 January 1986 – 30 September 2007**

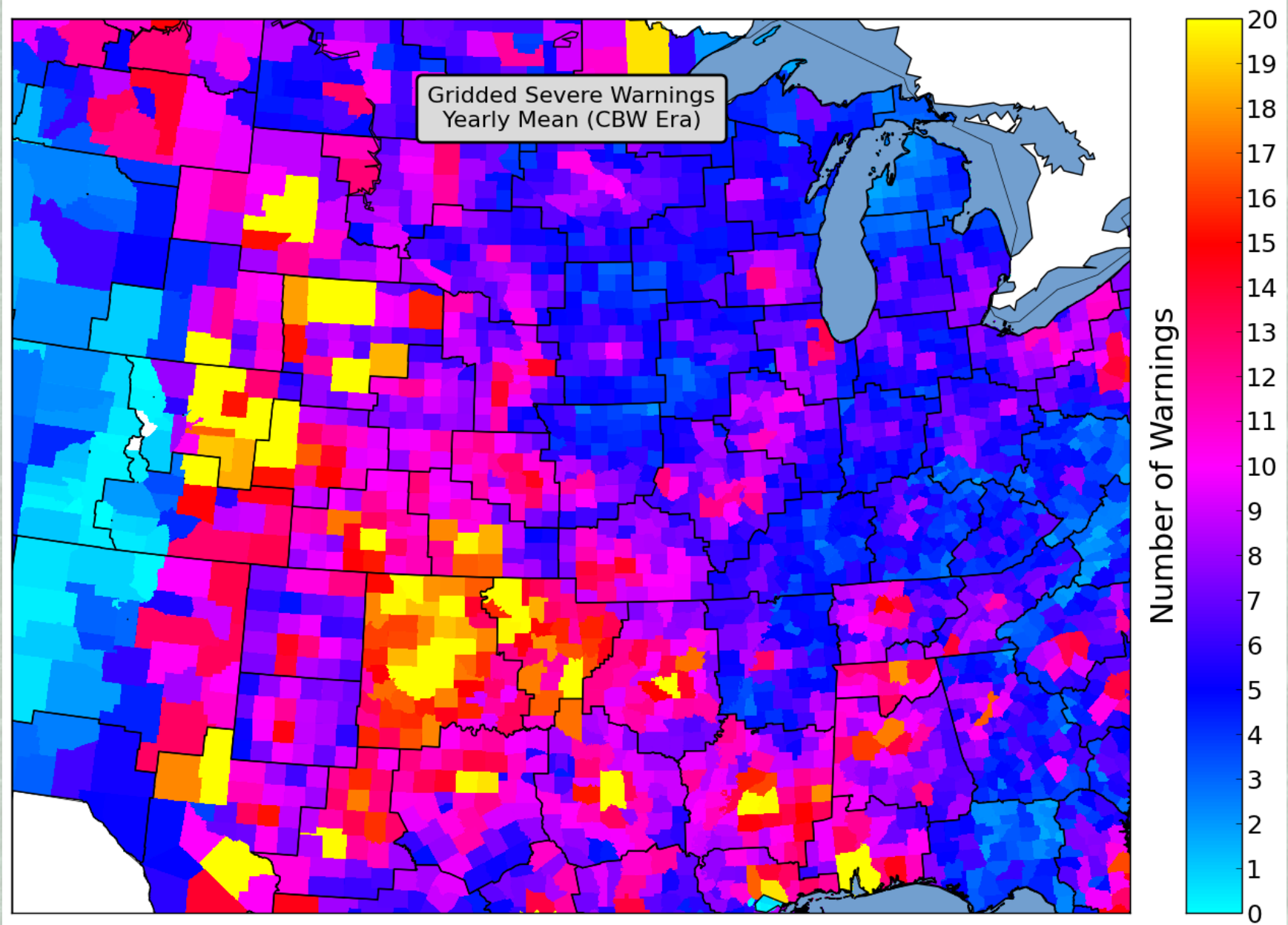
# Yearly Mean Severe Warnings – CBW Era



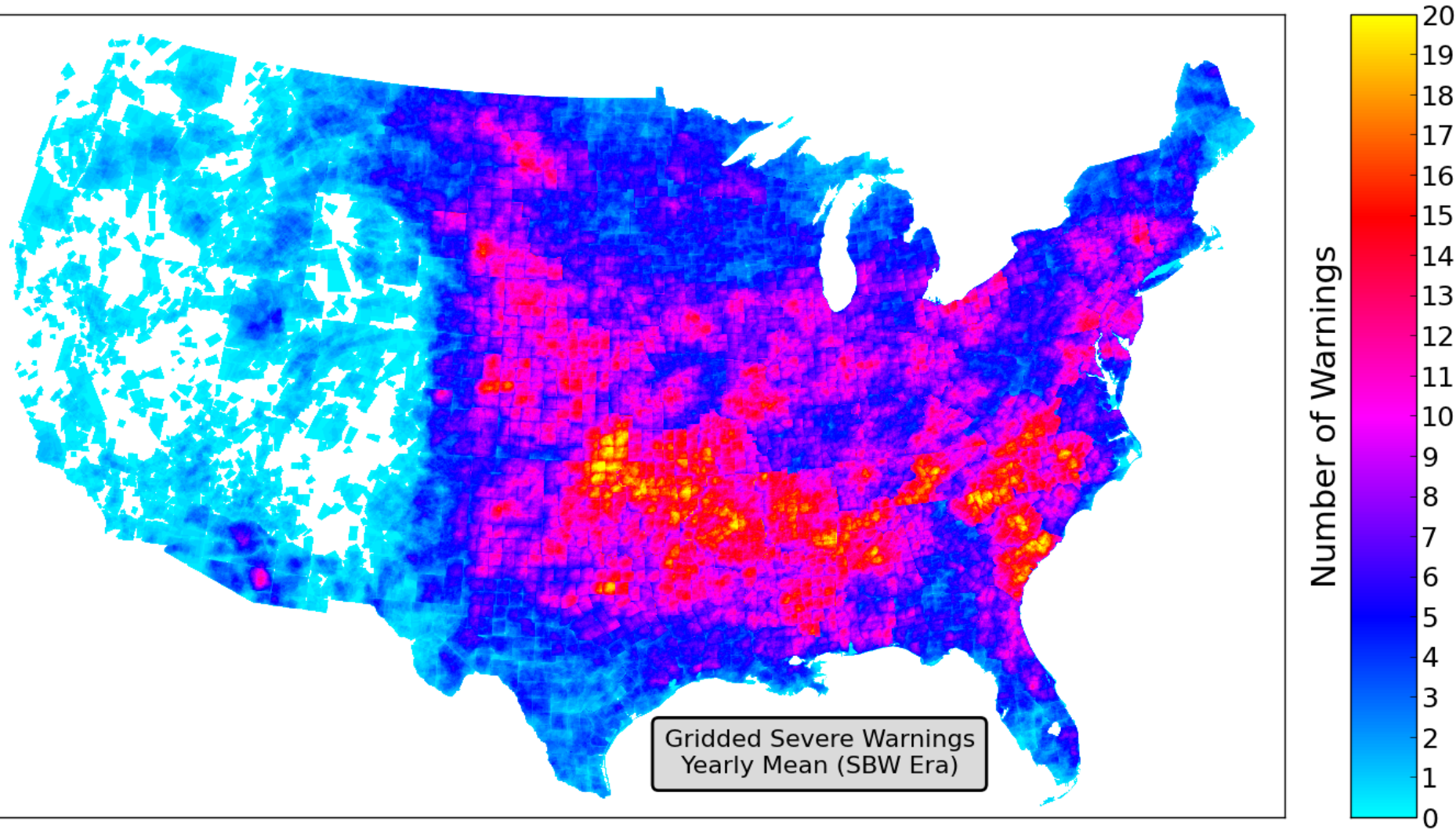
**CBW = 01 January 1986 – 30 September 2007**



# Yearly Mean Severe Warnings – CBW Era

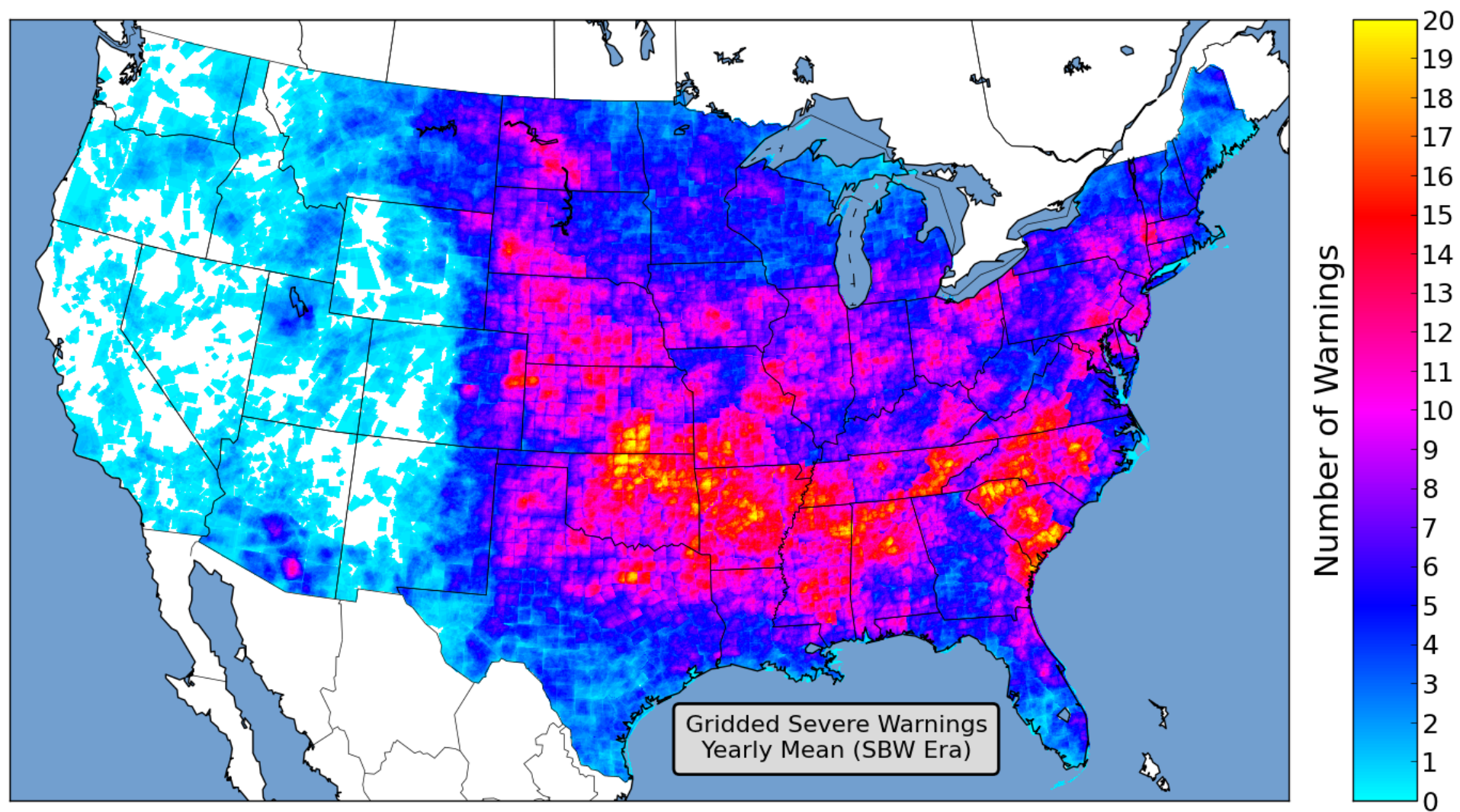


# Yearly Mean Severe Warnings – SBW Era



**SBW = 01 October 2007 – 31 December 2011**

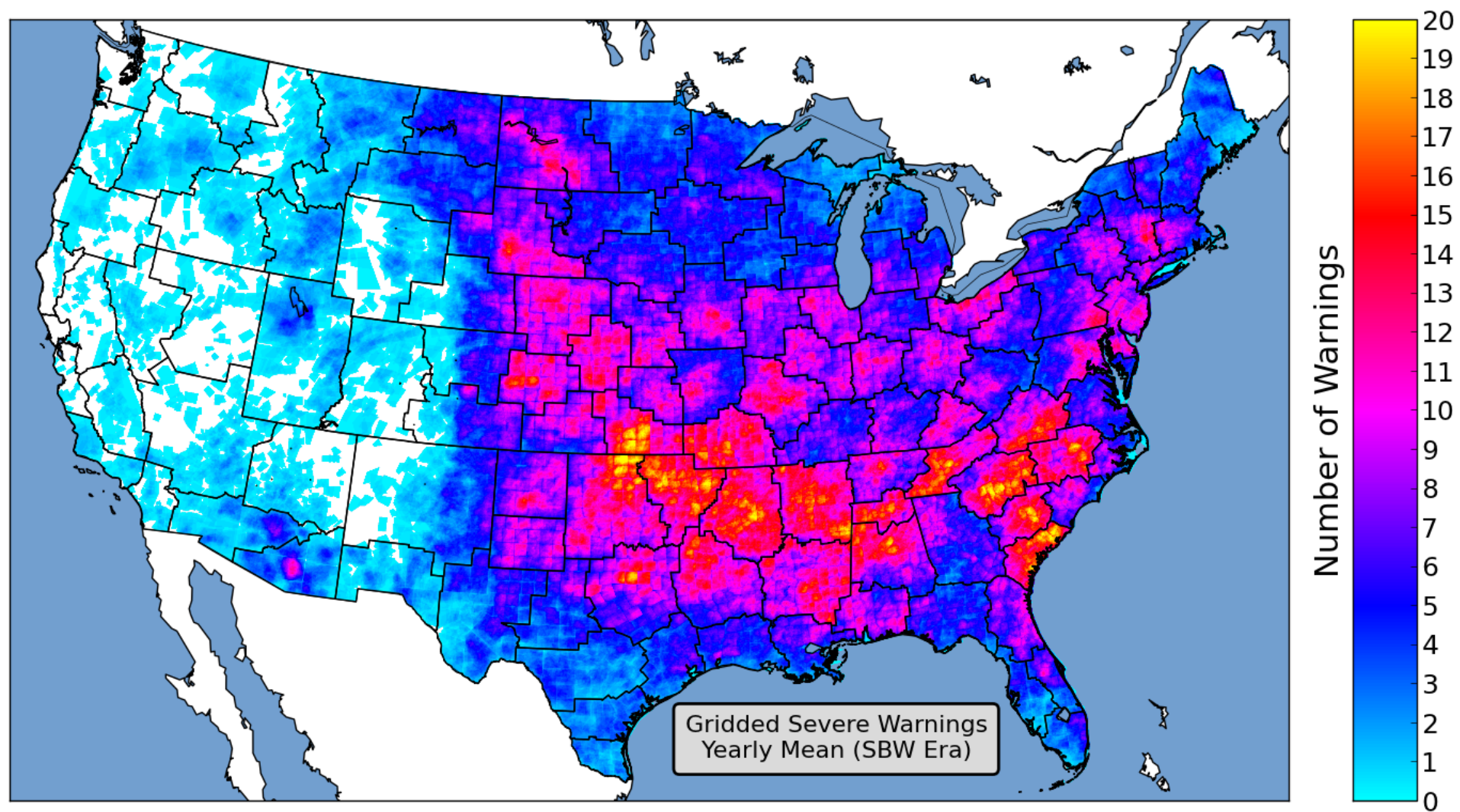
# Yearly Mean Severe Warnings – SBW Era



**SBW = 01 October 2007 – 31 December 2011**



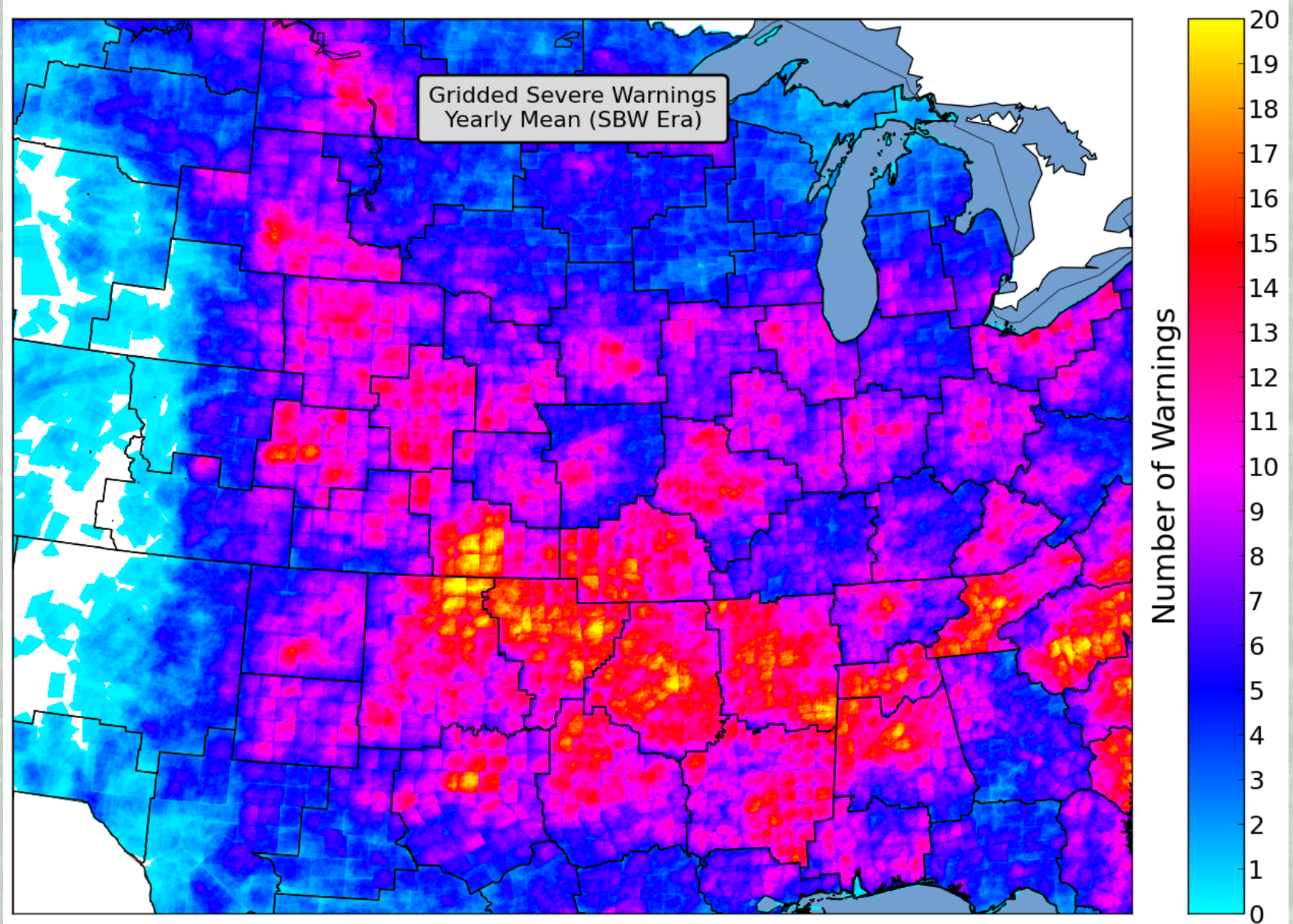
# Yearly Mean Severe Warnings – SBW Era



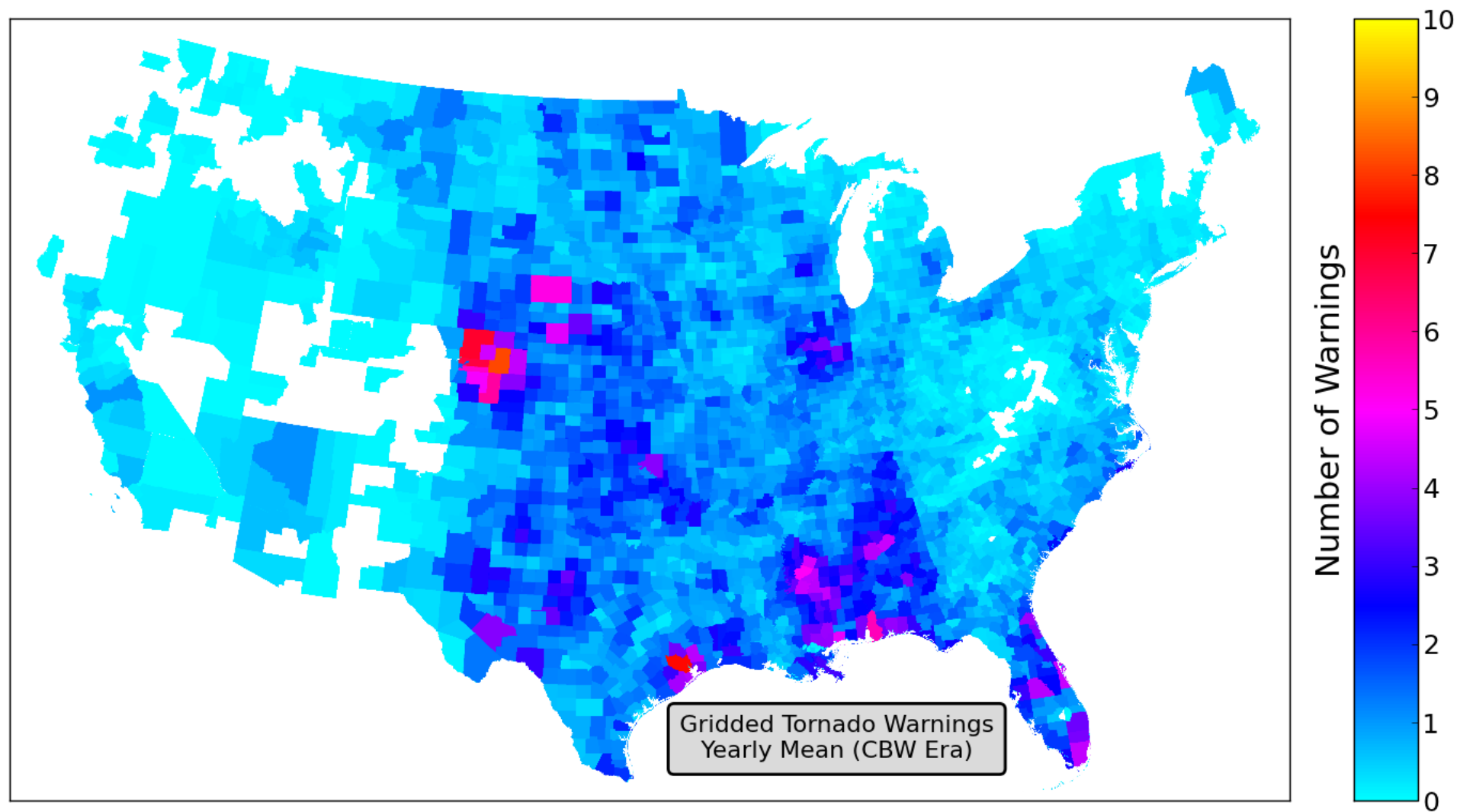
**SBW = 01 October 2007 – 31 December 2011**



# Yearly Mean Severe Warnings – SBW Era

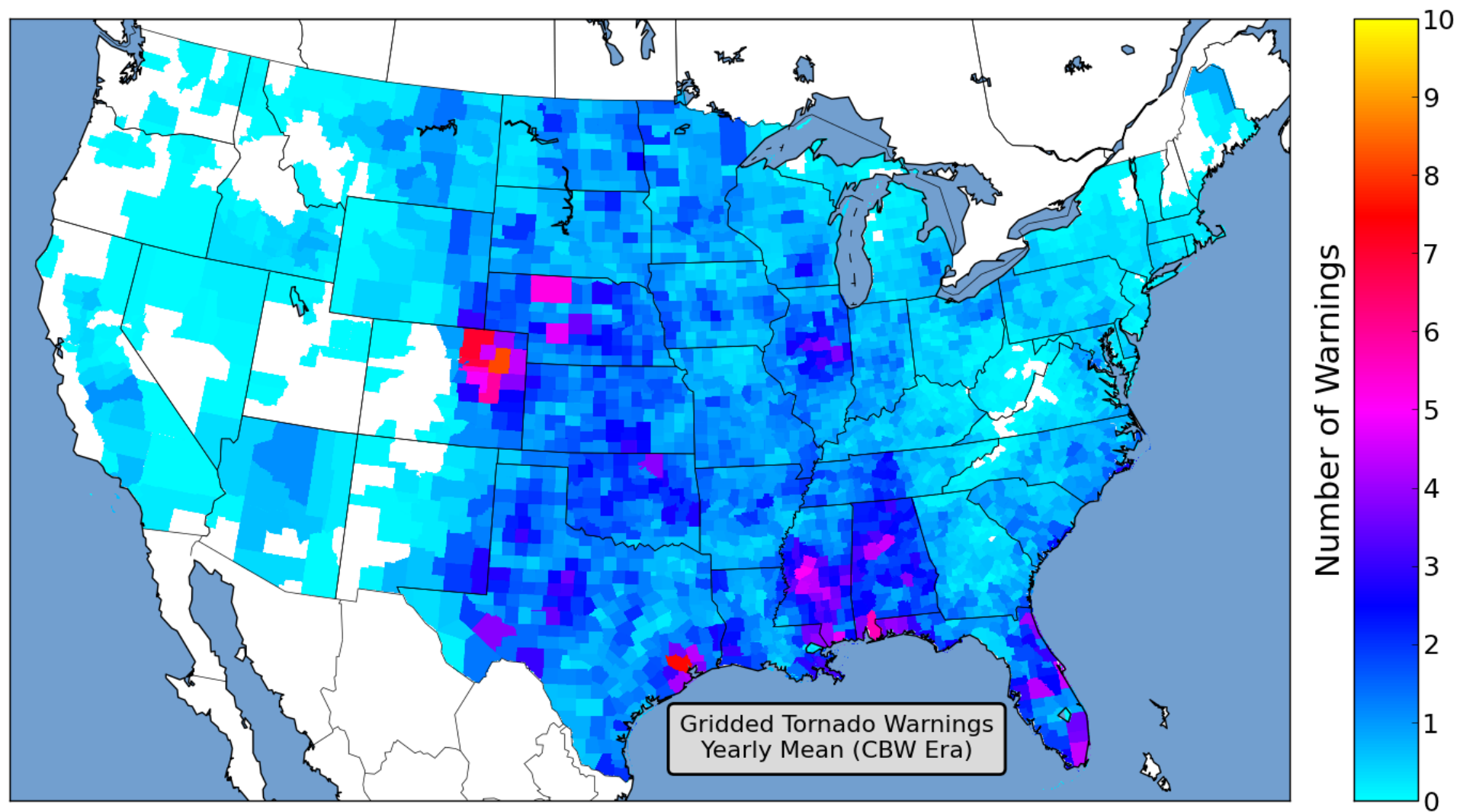


# Yearly Mean Tornado Warnings – CBW Era



**CBW = 01 January 1986 – 30 September 2007**

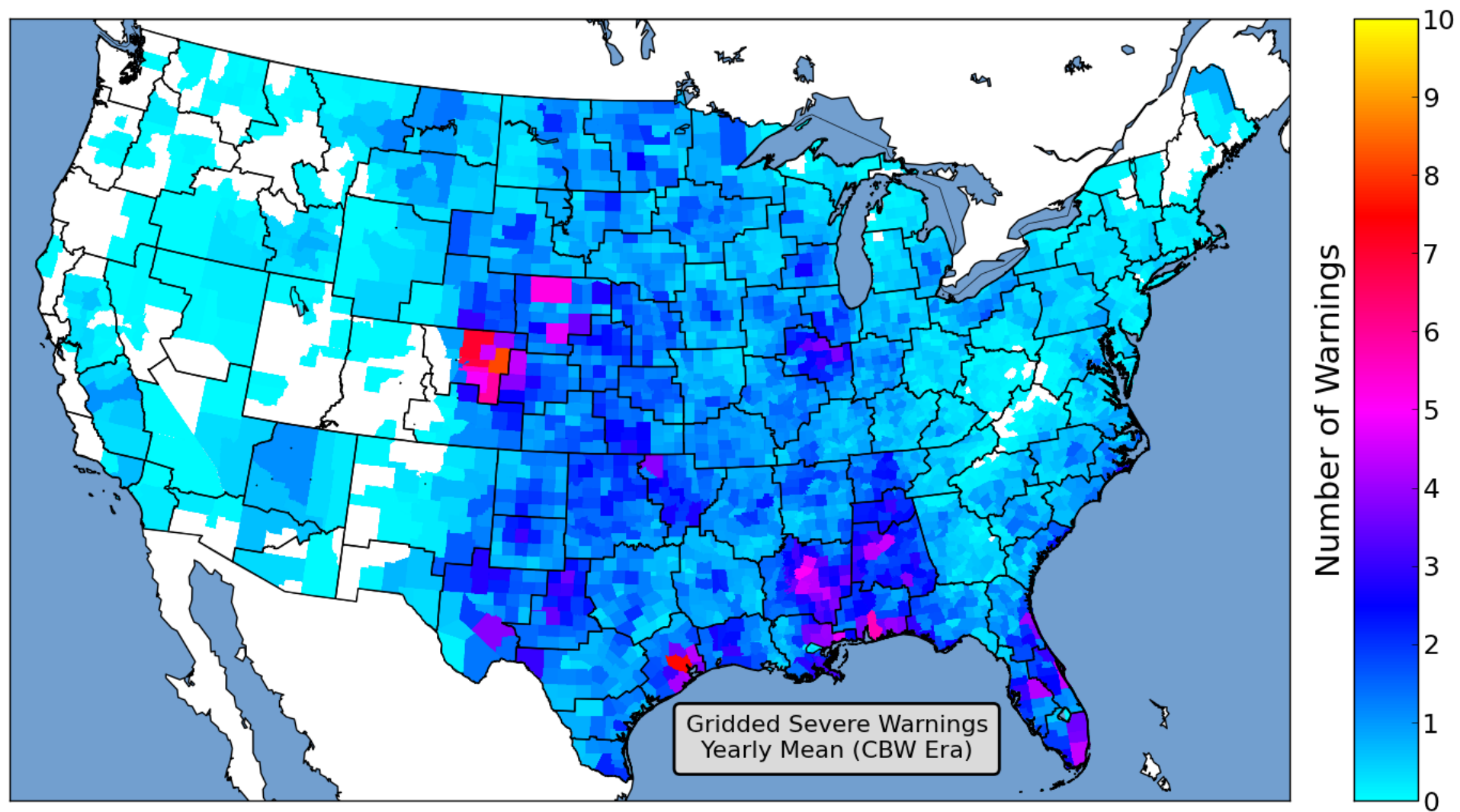
# Yearly Mean Tornado Warnings – CBW Era



**CBW = 01 January 1986 – 30 September 2007**

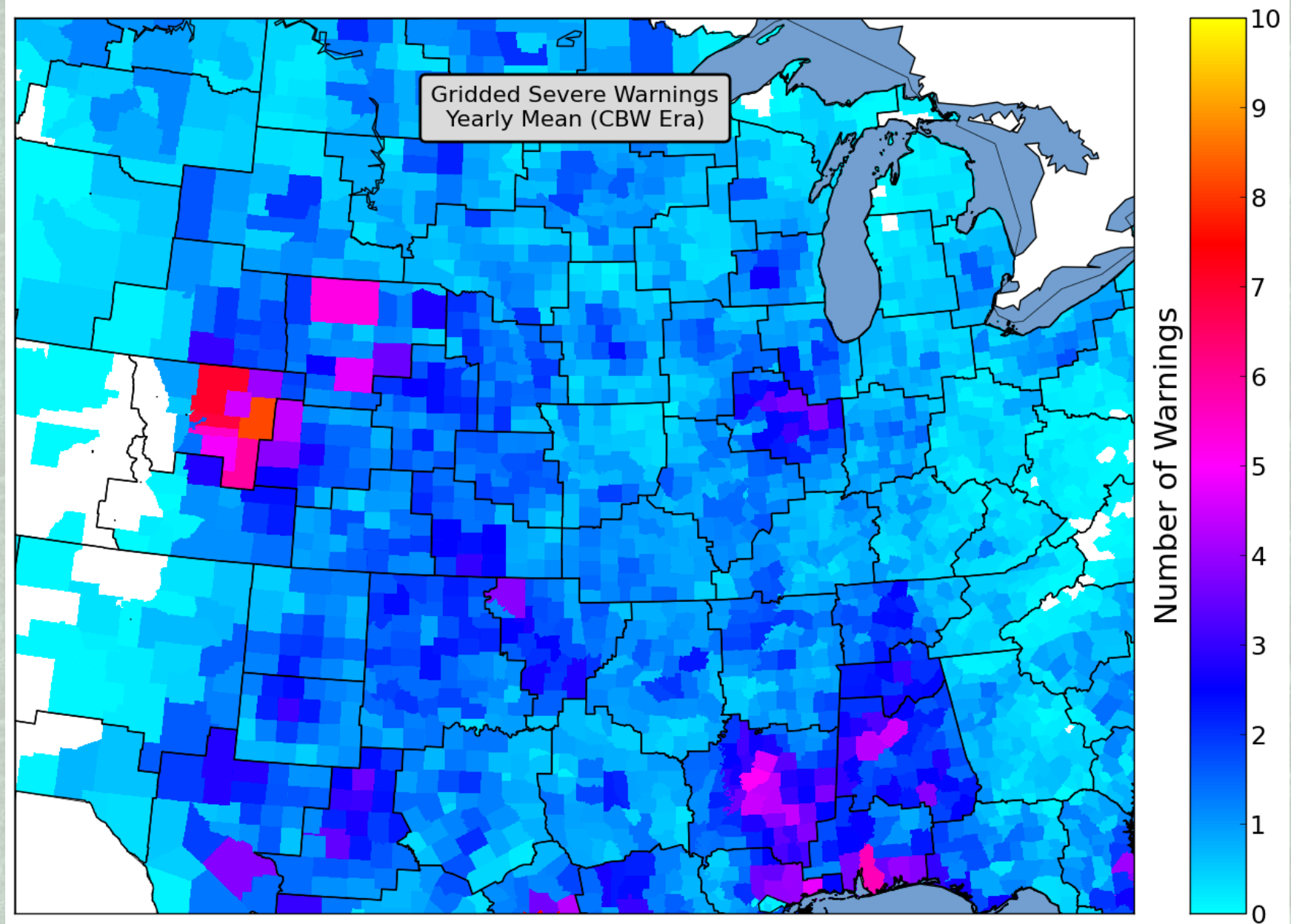


# Yearly Mean Tornado Warnings – CBW Era



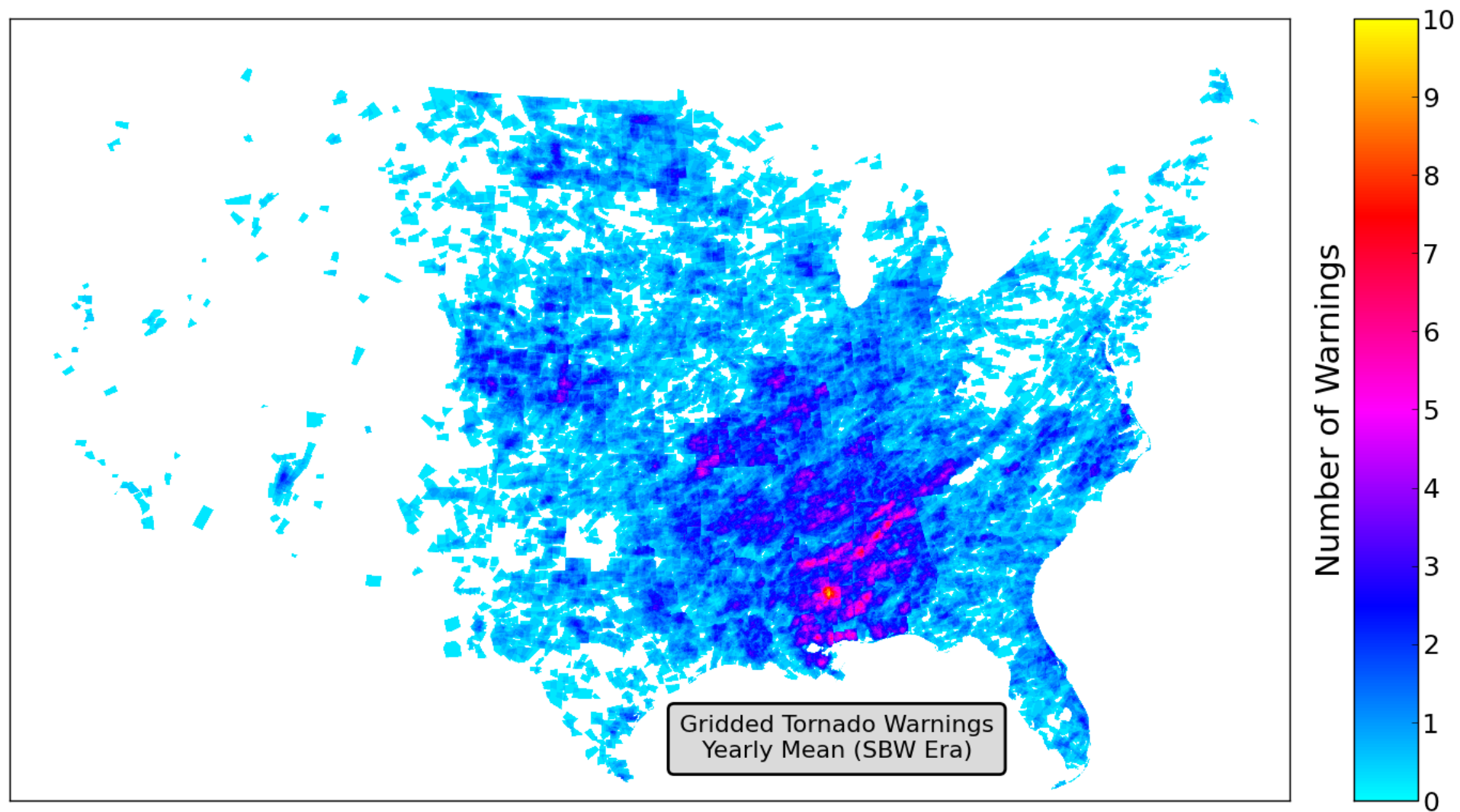
**CBW = 01 January 1986 – 30 September 2007**

# Yearly Mean Tornado Warnings – CBW Era



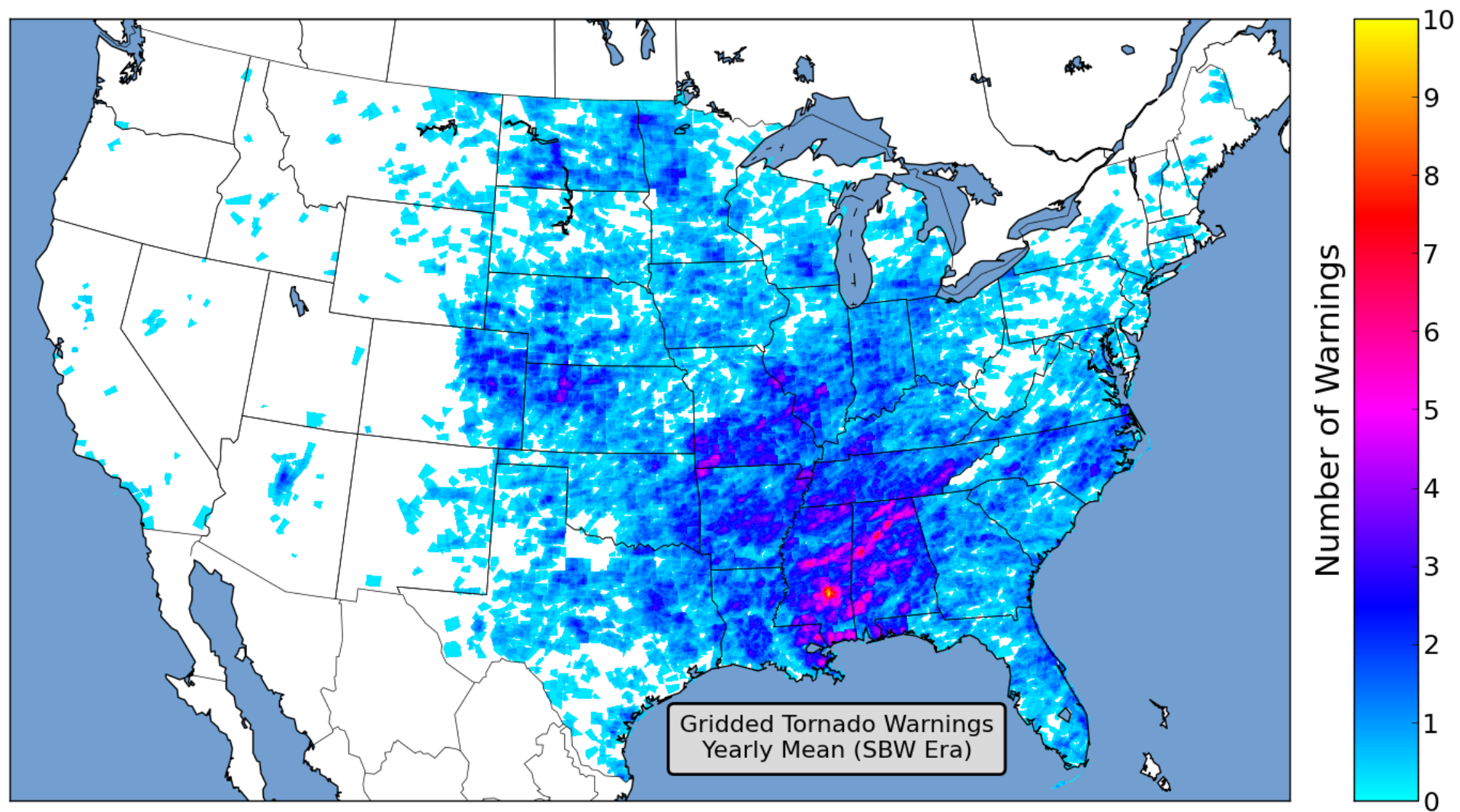


# Yearly Mean Tornado Warnings – SBW Era



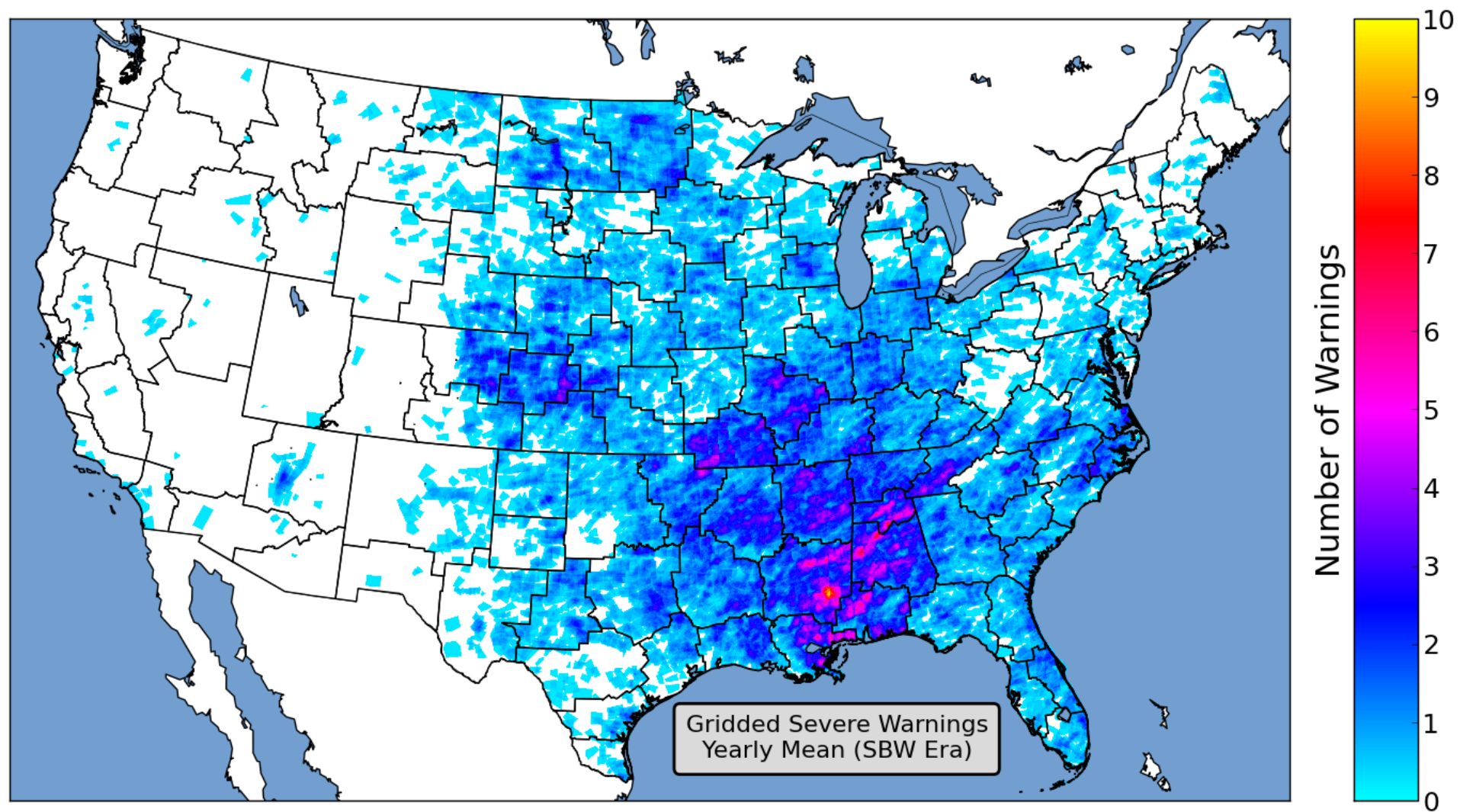
**SBW = 01 October 2007 – 31 December 2011**

# Yearly Mean Tornado Warnings – SBW Era



**SBW = 01 October 2007 – 31 December 2011**

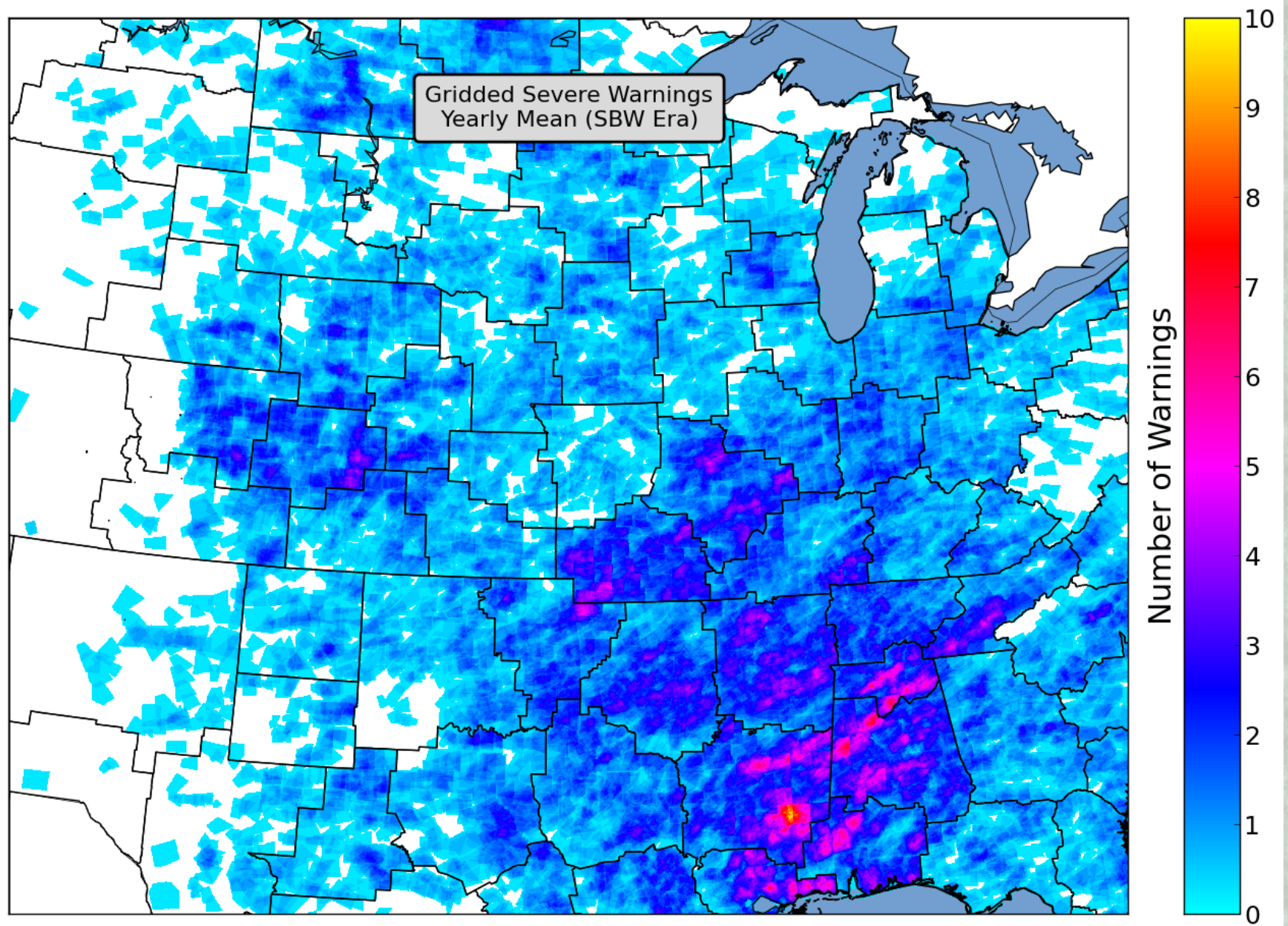
# Yearly Mean Tornado Warnings – SBW Era



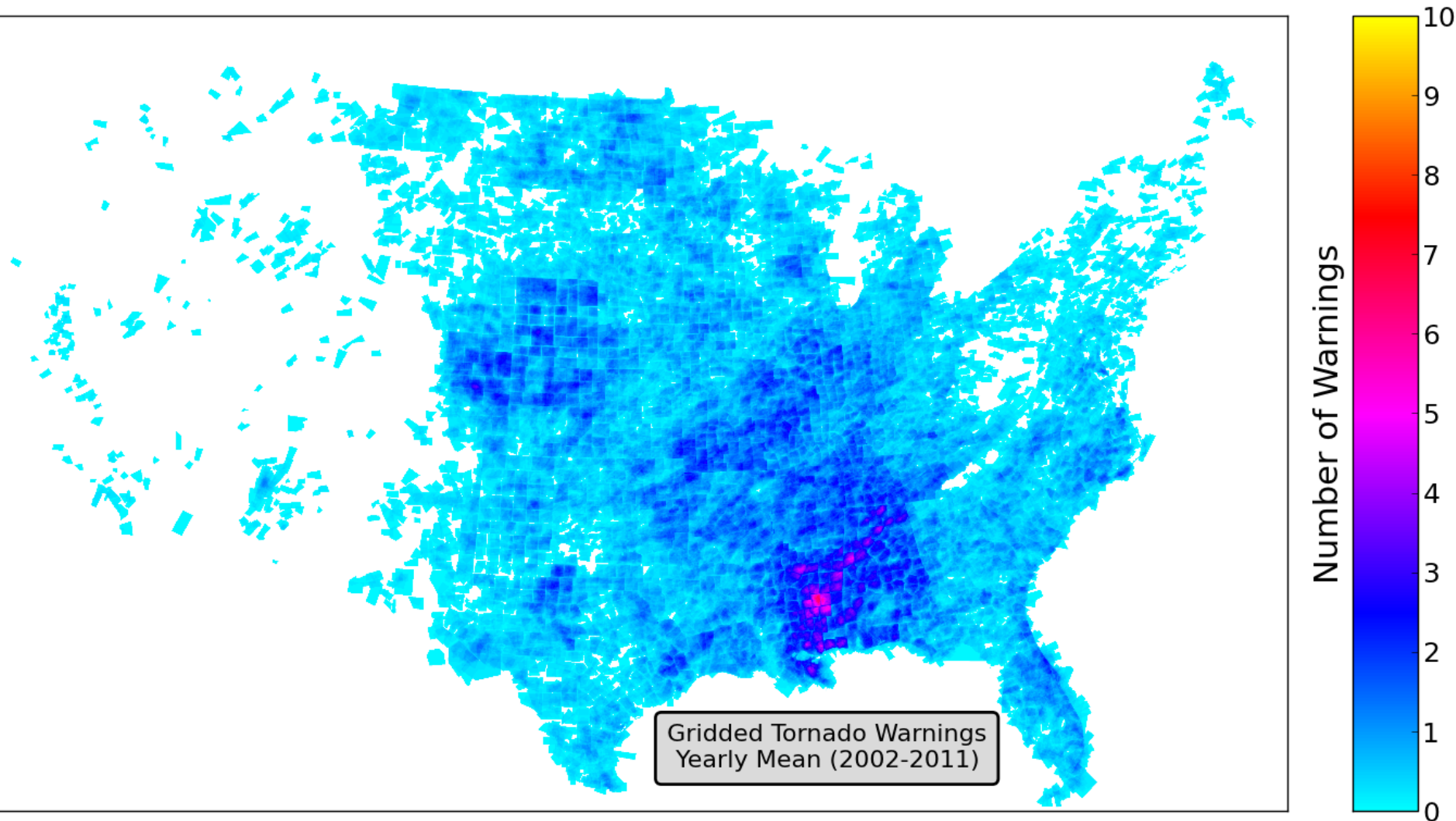
**SBW = 01 October 2007 – 31 December 2011**



# Yearly Mean Tornado Warnings – SBW Era

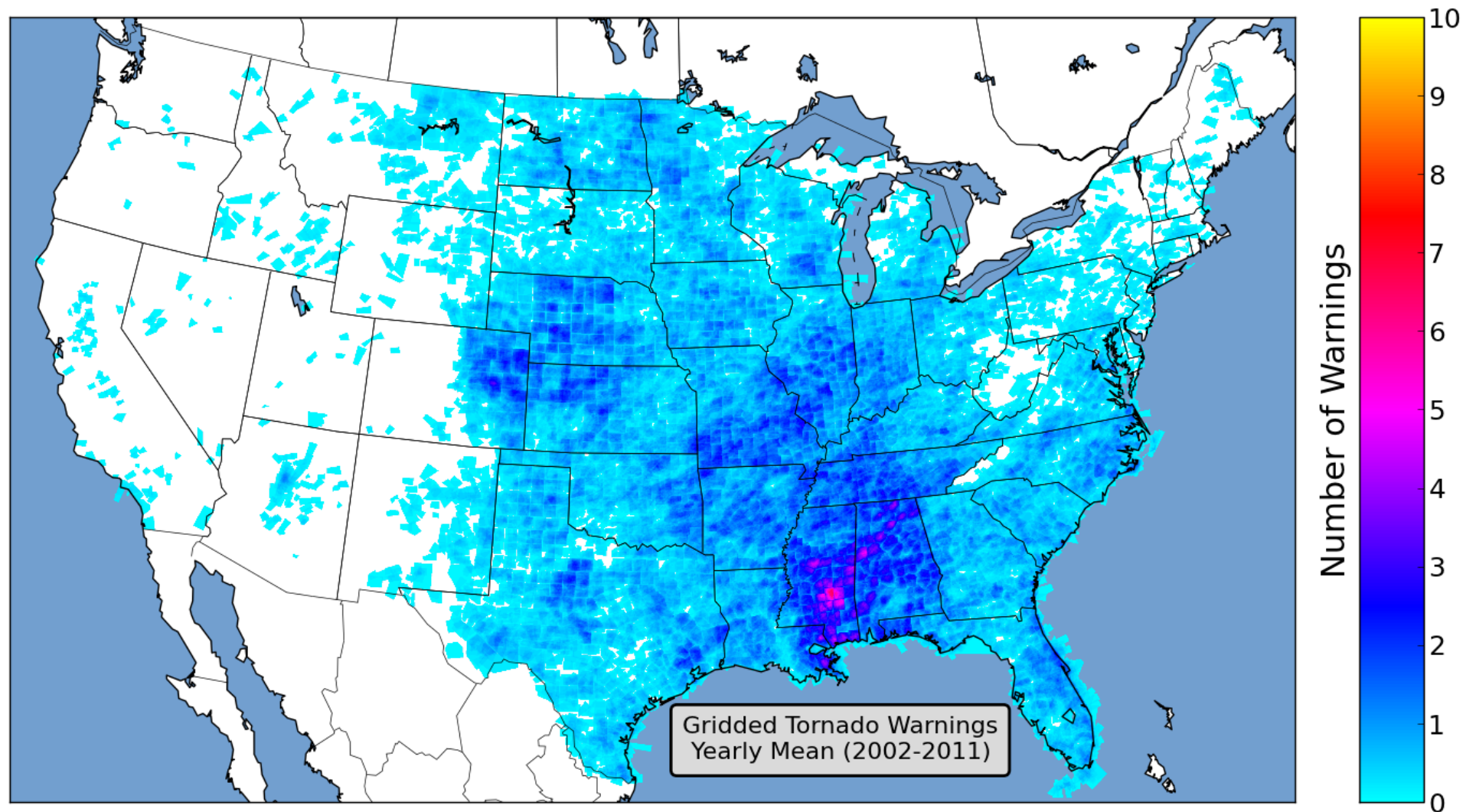


# Yearly Mean Tornado Warnings 2002 - 2011

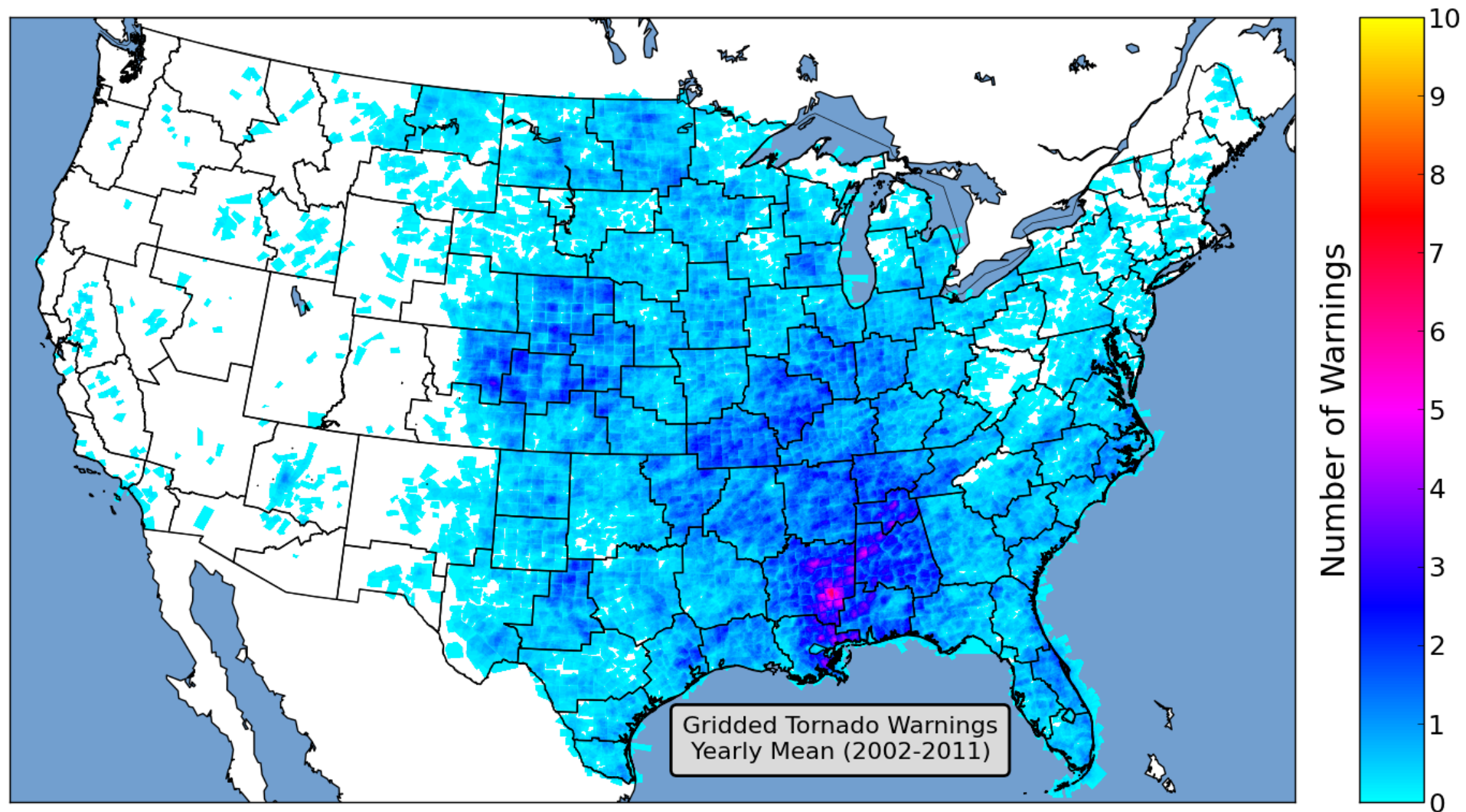




# Yearly Mean Tornado Warnings 2002 - 2011



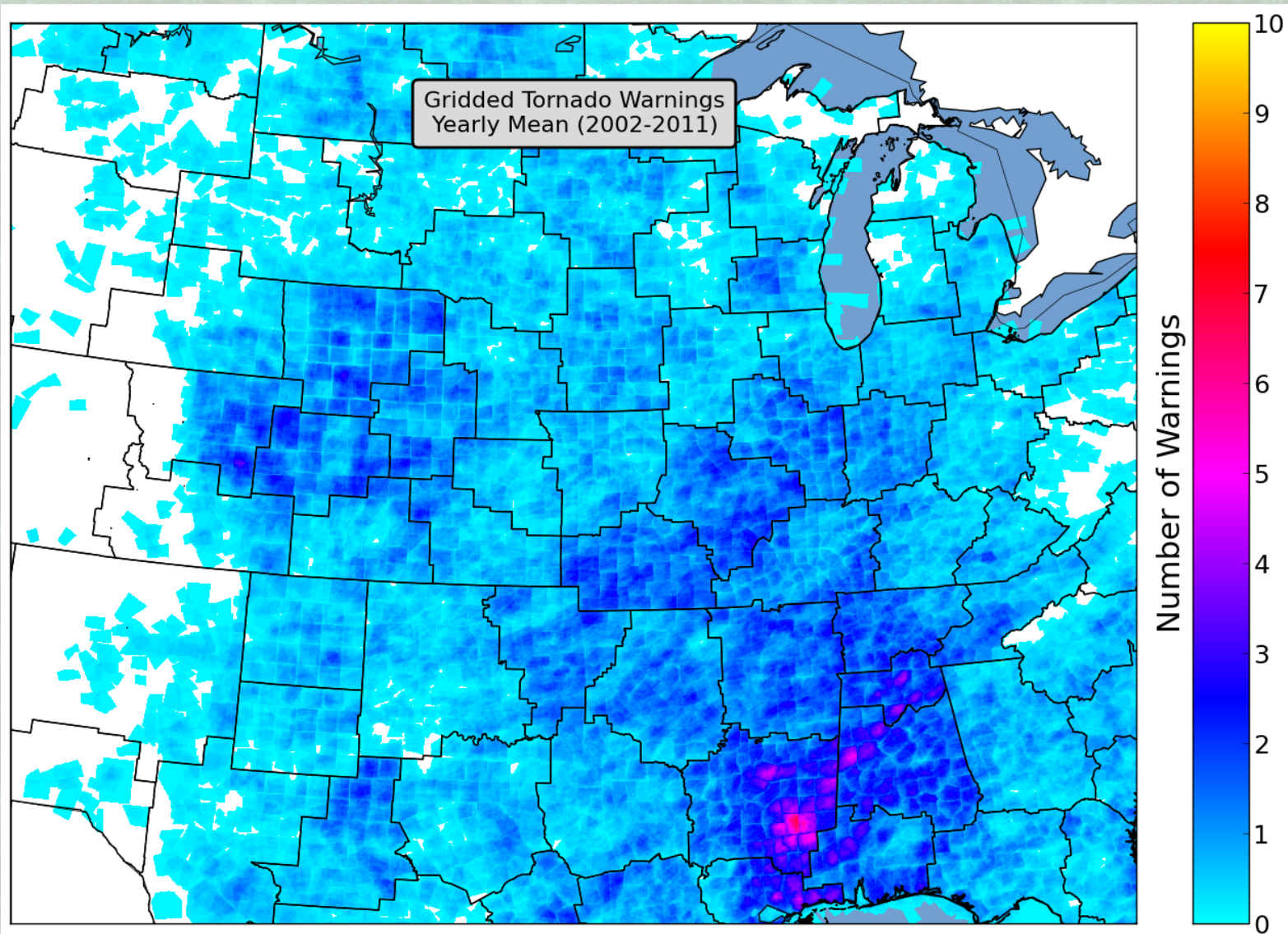
# Yearly Mean Tornado Warnings 2002 - 2011



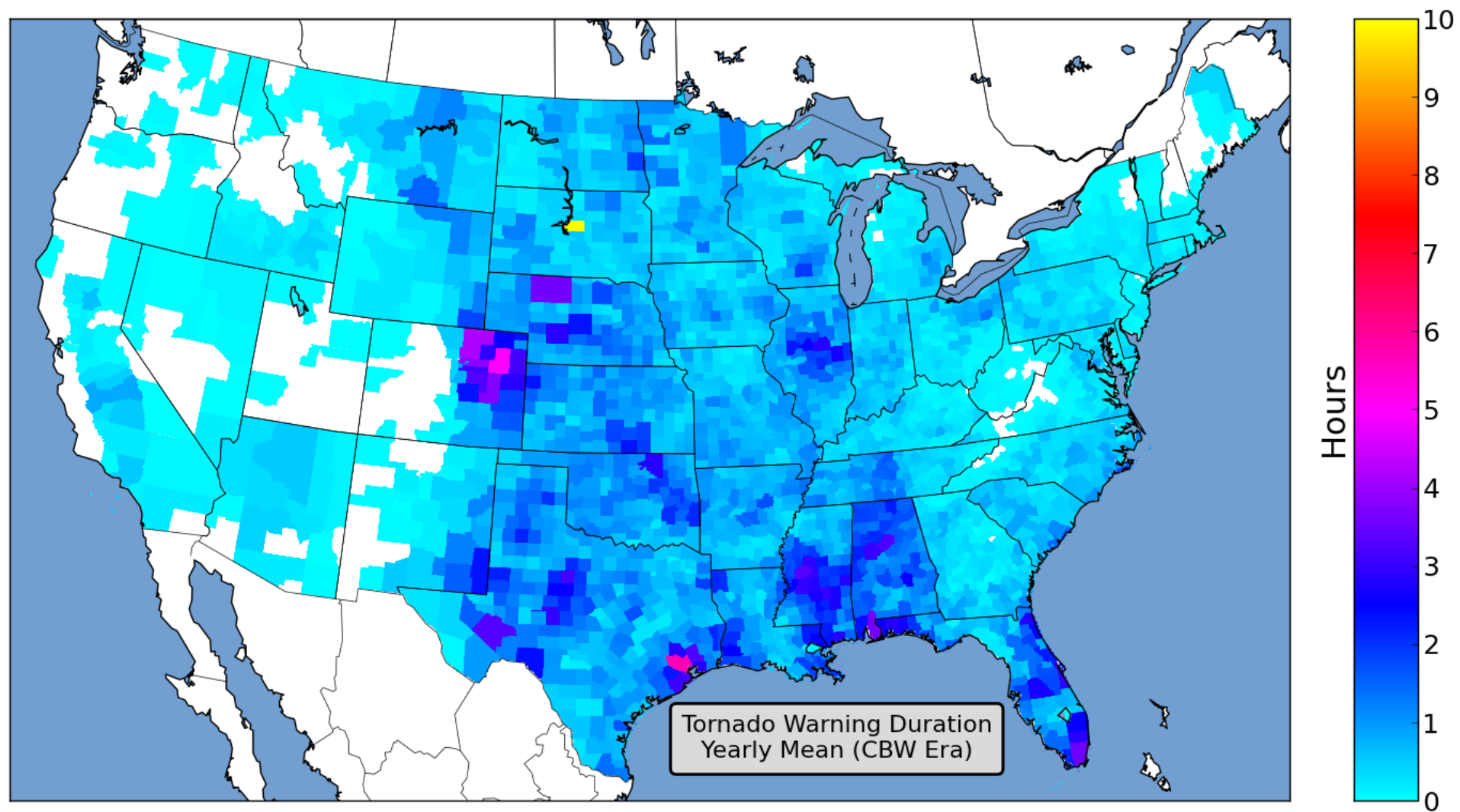


# Yearly Mean Tornado Warnings

## 2002 - 2011

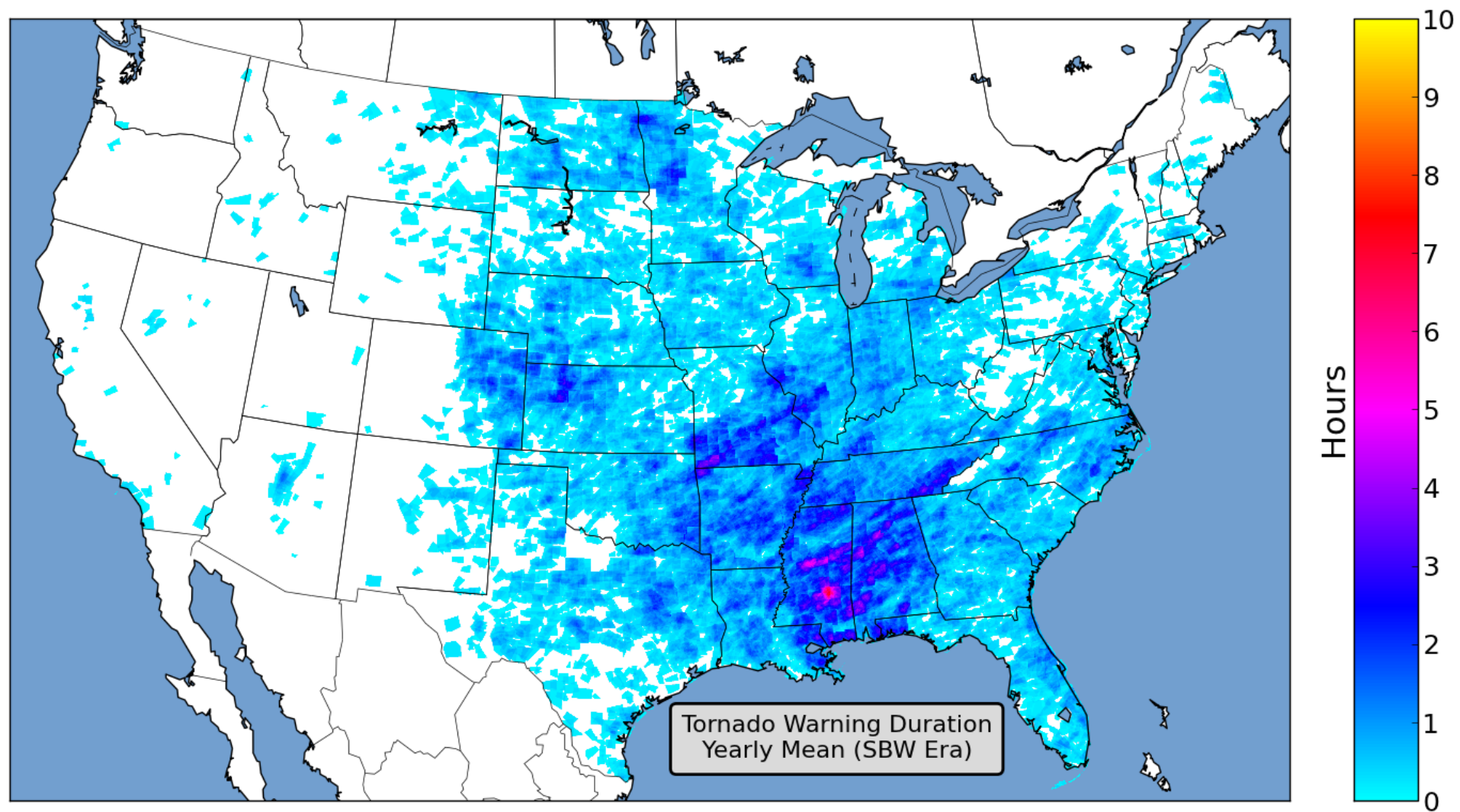


# Yearly Mean TOR Warn Hours – CBW Era





# Yearly Mean TOR Warn Hours – SBW Era



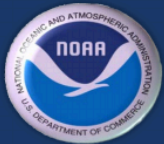
**The Severe Weather Community  
has a problem (problems?)...**

**Who is trying to address it (them?)?**

**Maybe a better question: Who  
actually knows what the  
problem is (problems are?)?**

# Taken from NWS CRH PDF

<http://www.crh.noaa.gov/images/crh/briefings/pdfs/2012ImpactBasedExperimentalProductCRH3.pdf>



## Impact Based Warning Experimental Product



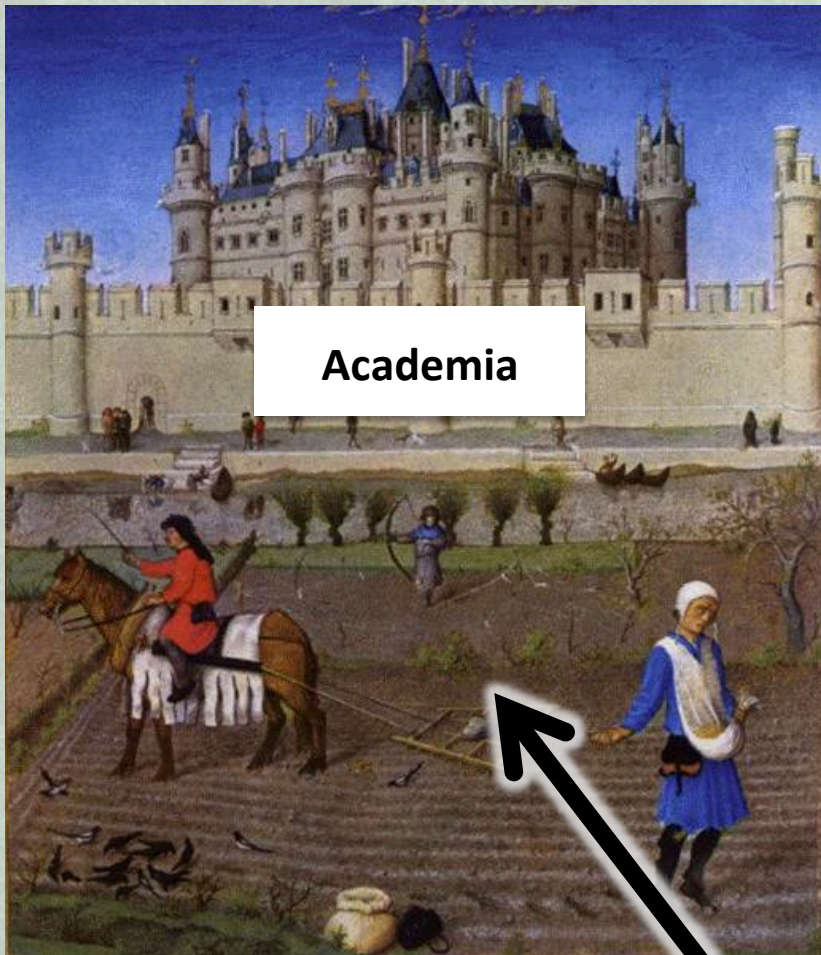
### Intended Outcomes:

- Optimize the convective warning system within the existing structure
- Motivate proper response to warnings by better distinguishing situational urgency
- Realign the warning message in terms of societal impacts
- Communicate recommended actions/precautions more concisely
- Evaluate ability to distinguish between low impact and high impact events





# Impacts-Based Tornado Warning Pilot Program - NWS Forecaster Perspective



Academia



Academia

NWS Forecasters



# Impacts-Based Tornado Warning Pilot Program - Academic Perspective



# Impacts-Based Tornado Warning Pilot Program - Public Perspective

**Favorite TV  
Meteorologist**

**NWS Forecasters**

**Academia**





# Impacts-Based Tornado Warning Pilot Program - Public Perspective

msn. **now** WHAT'S TRENDING  
Monday, April 2, 7:20 am



Weather service fights apathy  
with fear-mongering

## New Tornado Warnings Aim to Scare

by **weather.com** and The Associated Press

'UNSURVIVABLE!' New tornado warnings aim to scare

By BILL DRAPER, Associated Press – 1 day ago  +1  0

[Home](#) > [News](#) : Story

National Weather service plans to "scare you safe"

Posted: 1 hr, 3 mins ago

Weather Service to test more graphic  
tornado warnings

# Impacts-Based Tornado Warning Pilot Program - Public Perspective

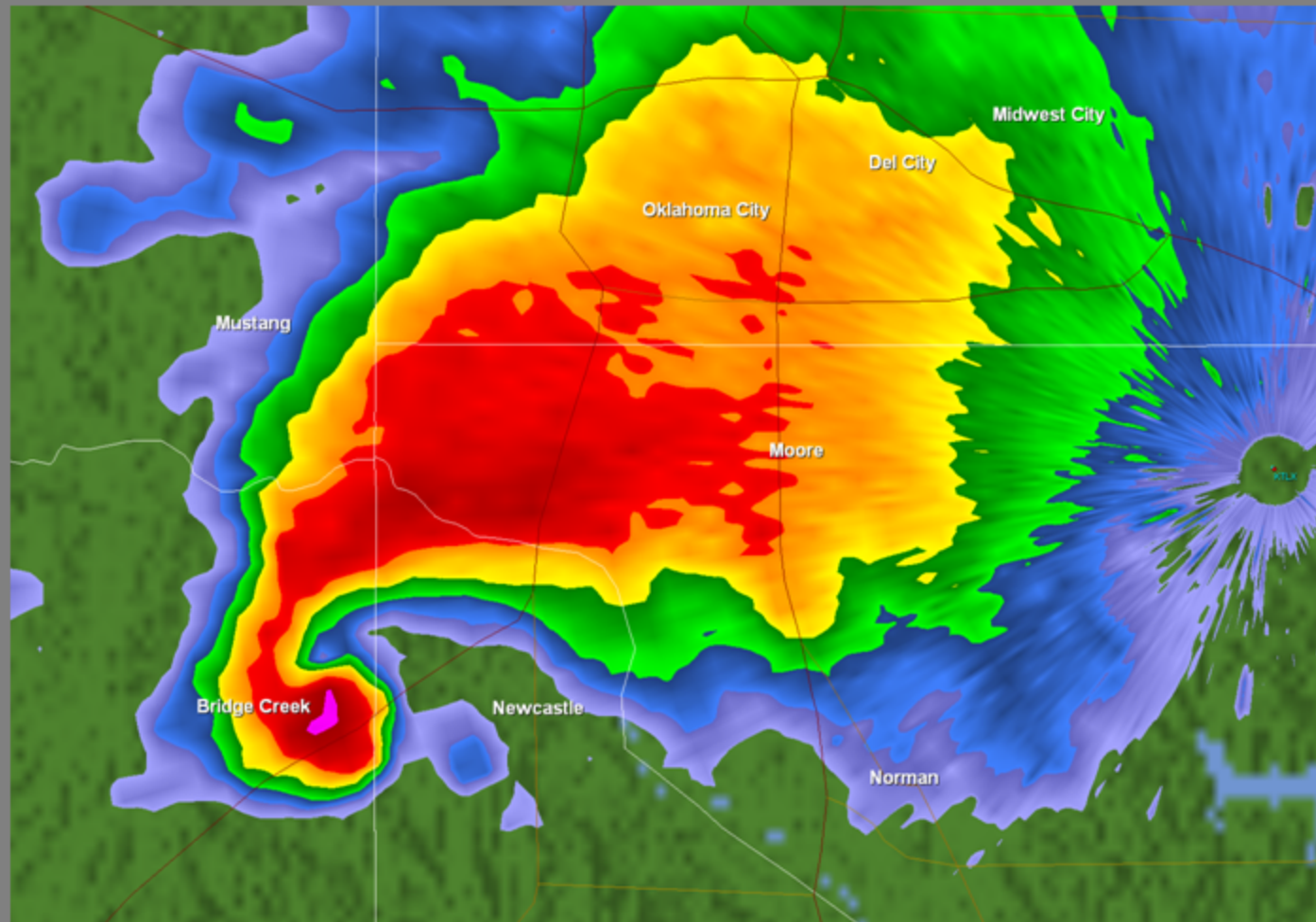
- “If this is a joke, it’s kind of tacky. I don’t think people who have lost their homes in tornadoes will think it’s very funny...”
- “Did they ever stop to think that maybe the reason that people never heed their warnings is because the Weather Channel already tends to over hype things? Remember last year when Hurricane Irene was supposed to wreck NYC? Didn’t happen. All this system is going to do is make people even more apathetic than they were before. If the Weather Channel really wants people to take them seriously, they should focus on accuracy instead of sensationalism.”
- “Yes, you could use terms like that, and they will work for awhile. But then, people will get used to them, and ignore them, because they just survived the ‘unsurvivable’. So now what? ... Eventually, people get desensitized to all of the gore, so you may as well stick to the warnings that they’re already used to ignoring.”
- “Trying to frighten broadcast audiences seems foolish, as fear-mongering usually sets the state for a public relations disaster once the cards are on the table. Surely these announcers can devise better ways to get people’s attention and improve their own credibility, the principal facet of a successful mentality.”
- “The main reason people do not heed the weather warnings are because they over state the severity and we have heard wolf to many times. Try downgrading your BS!! And report the actual condition then people will probably listen and heed your warning. You want to be mellow dramatic then become as actor or actress – idiots.



# **How Might This Play Out?**

**Let's take a look at the only official  
NWS product that can be considered  
an enhanced Tornado Warning – the  
Tornado Emergency**

# TORNADO EMERGENCY



...TORNADO EMERGENCY IN SOUTH OKLAHOMA CITY METRO AREA...

AT 657 PM CDT...A LARGE TORNADO WAS MOVING ALONG INTERSTATE 44 WEST OF NEWCASTLE. ON ITS PRESENT PATH...THIS LARGE DAMAGING TORNADO WILL ENTER SOUTHWEST SECTIONS OF THE OKLAHOMA CITY METRO AREA BETWEEN 715 PM AND 730 PM. PERSONS IN MOORE AND SOUTH OKLAHOMA CITY SHOULD TAKE IMMEDIATE TORNADO PRECAUTIONS!

# When to Issue a Tornado Emergency?

“In exceedingly rare situations, when a severe threat to human life and catastrophic damage from a tornado is imminent or ongoing, the forecaster may use the terminology **"TORNADO EMERGENCY FOR [GEOGRAPHIC AREA]"** in the third bullet of the warning. Additionally, in such a situation, this terminology should only be used when reliable sources confirm a tornado, or there is clear radar evidence of the existence of a damaging tornado such as the observation of debris.”

NWSI 10-511 APRIL 19, 2010

<http://www.nws.noaa.gov/directives/sym/pd01005011curr.pdf>

# When to Issue a Tornado Emergency?

“In exceedingly rare situations, when a severe threat to human life and catastrophic damage from a tornado is imminent or ongoing, the forecaster may use the terminology **"TORNADO EMERGENCY FOR [GEOGRAPHIC AREA]"** in the third bullet of the warning. Additionally, in such a situation, this terminology should only be used when reliable sources confirm a tornado, or there is clear radar evidence of the existence of a damaging tornado such as the observation of debris.”

NWSI 10-511 APRIL 19, 2010

<http://www.nws.noaa.gov/directives/sym/pd01005011curr.pdf>



# **Implications of the NWS Directive**

**Success Ratio: 1**

**False Alarm Ratio: 0**

# The Directive in Picture Form!



# Method: Defining **Tornado Emergency**

- Begins: Tornado Warning or severe weather statement contains the phrase “**TORNADO EMERGENCY**”
- Ends: Initial (parent) Tornado Warning expires\*
- Possible to have multiple **Tornado Emergencies** for the same tornado

# **\*Exceptions Must Be Made**

825

WWUS53 KEAX 042232

SVSEAX

KSC091-103-209-MOC047-095-165-042300-

SEVERE WEATHER STATEMENT

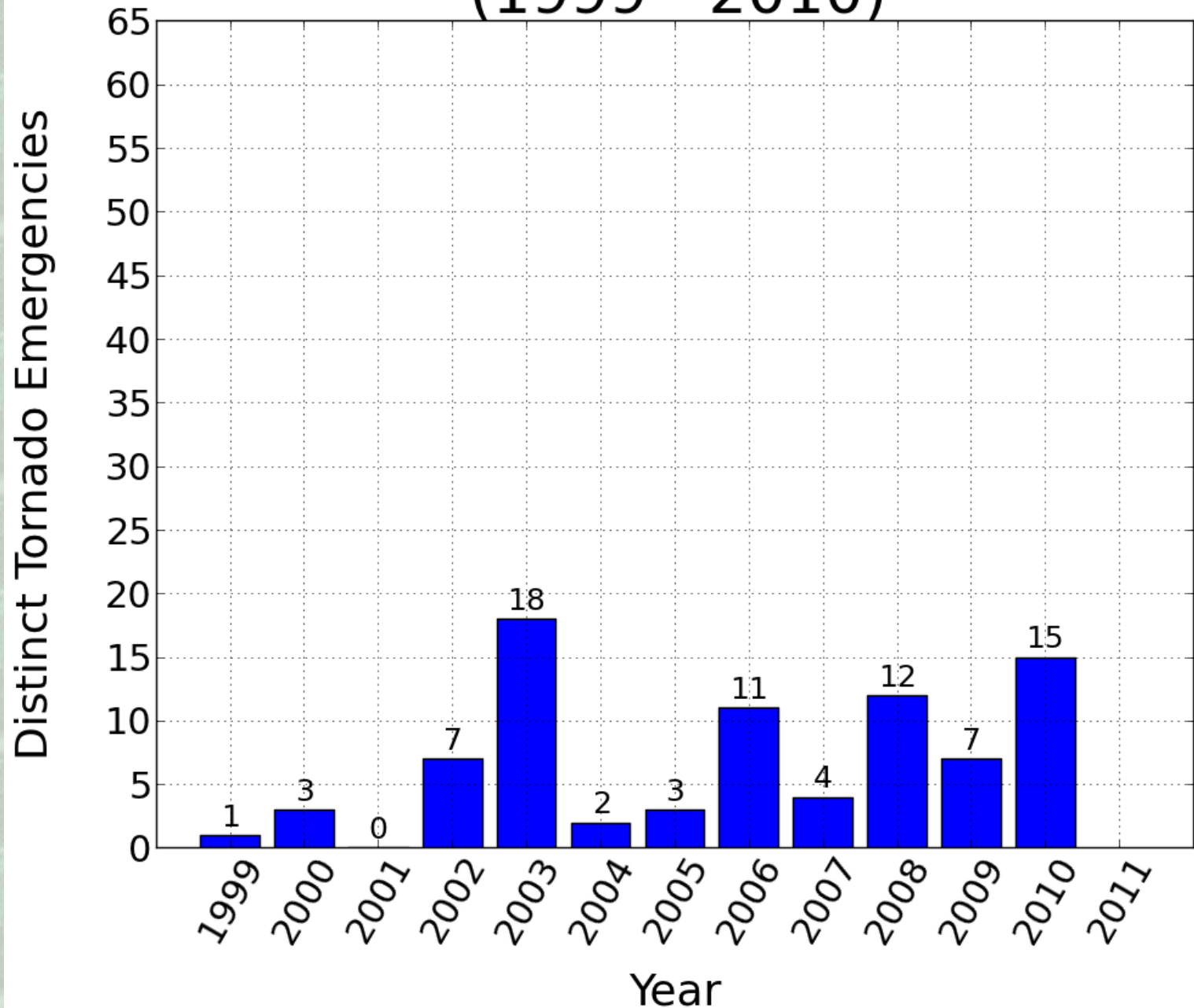
NATIONAL WEATHER SERVICE KANSAS CITY/PLEASANT HILL MO

527 PM CDT SUN MAY 4 2003

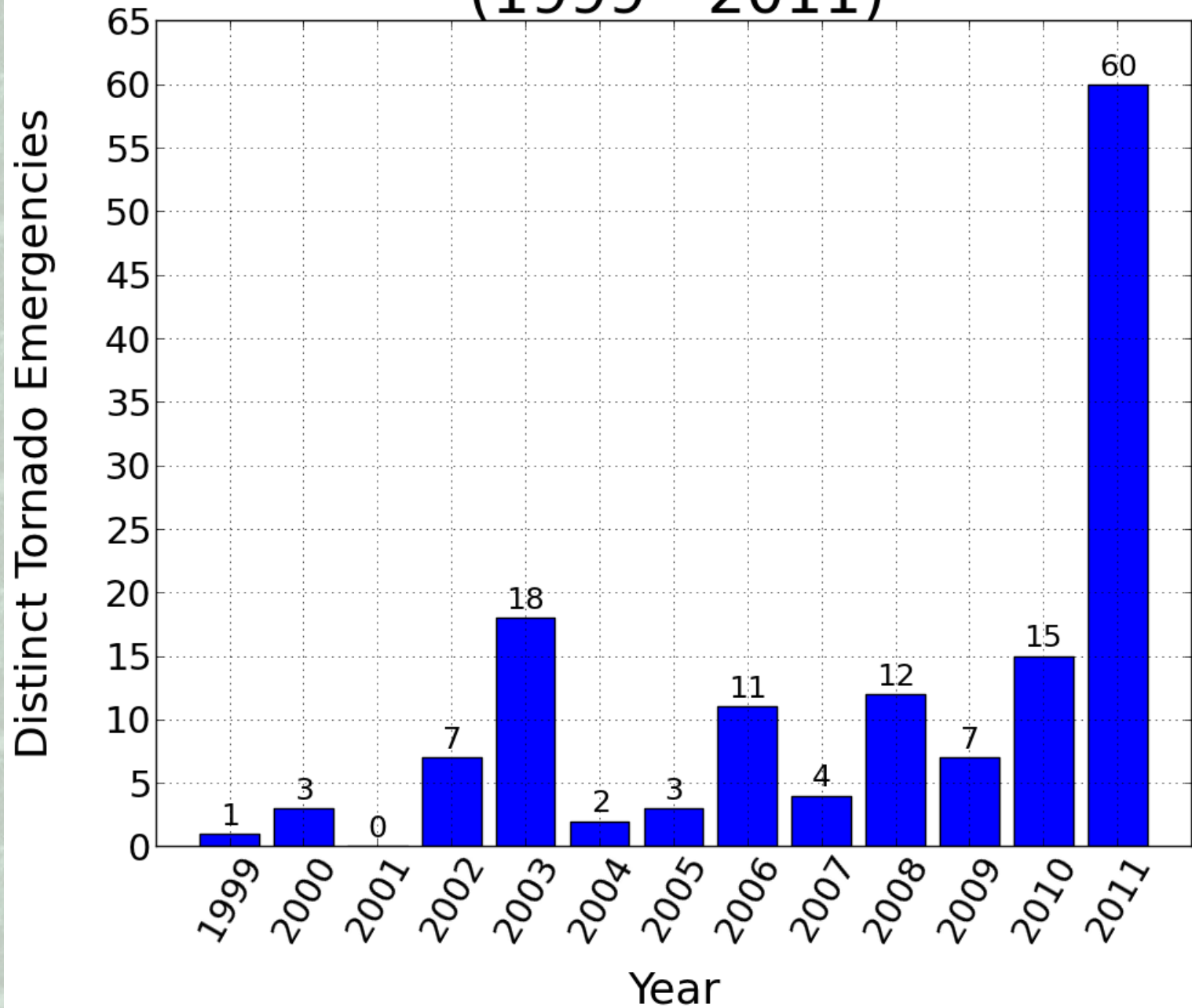
...TORNADO EMERGENCY REMAINS IN EFFECT THROUGH THE  
EVENING HOURS FOR THE METRO...



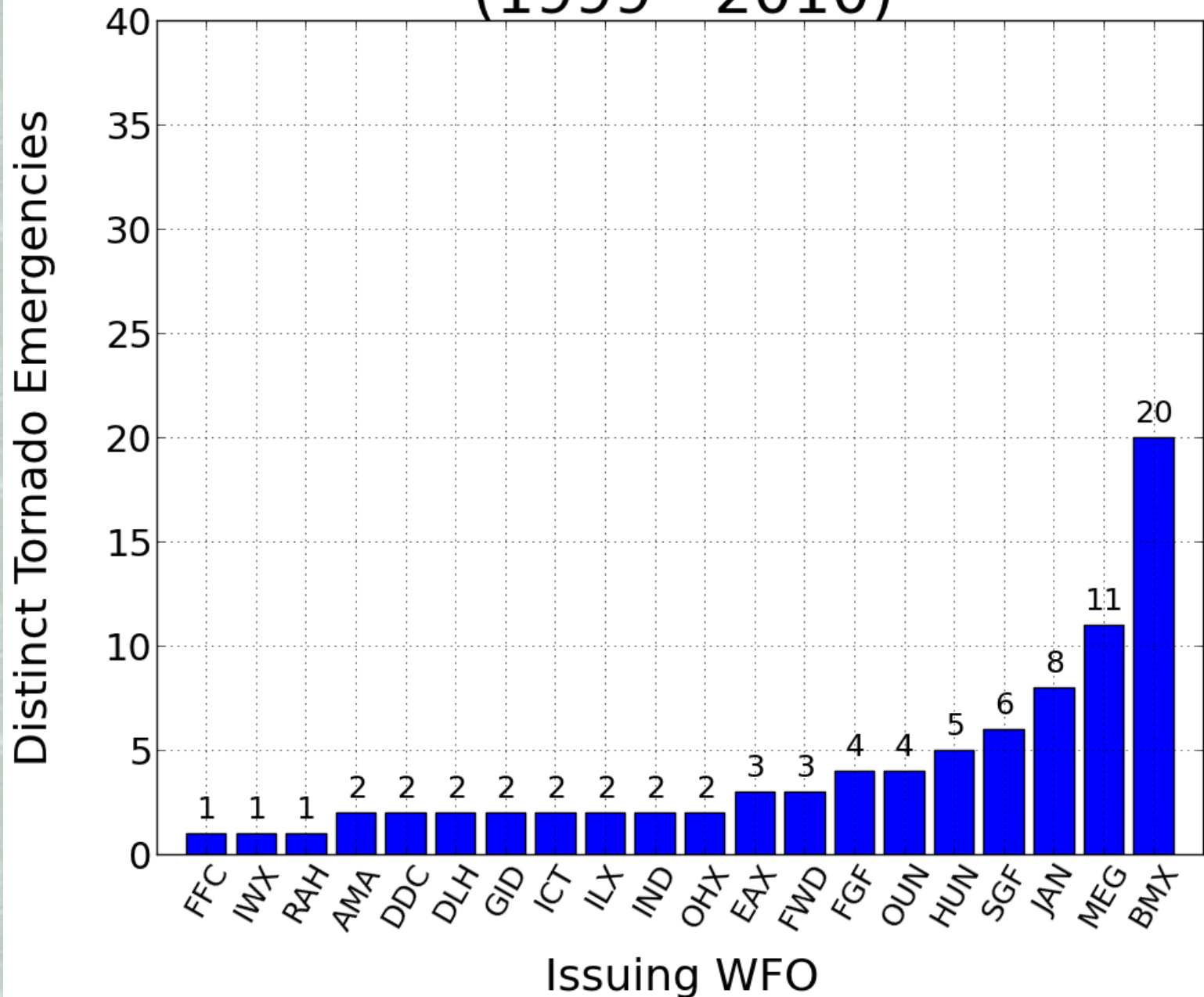
# Tornado Emergencies by Year (1999 - 2010)



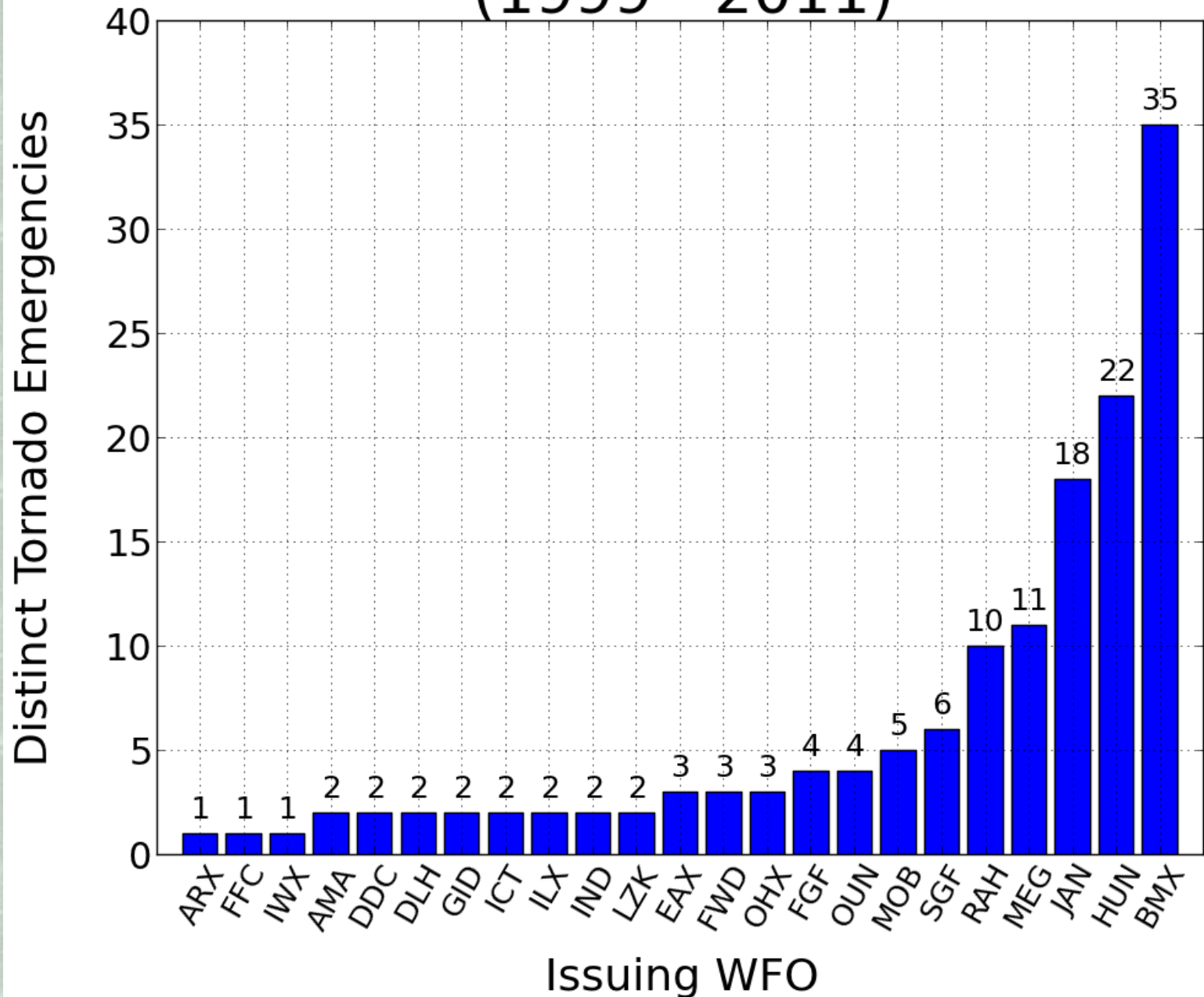
# Tornado Emergencies by Year (1999 - 2011)



# Tornado Emergencies by WFO (1999 - 2010)



# Tornado Emergencies by WFO (1999 - 2011)





# Tornado Emergencies (1999 – 2010)

Number of Tornado Emergencies

5  
4  
3  
2  
1

Gridded Tornado Emergencies  
1999-2010



# Tornado Emergencies (1999 – 2011)

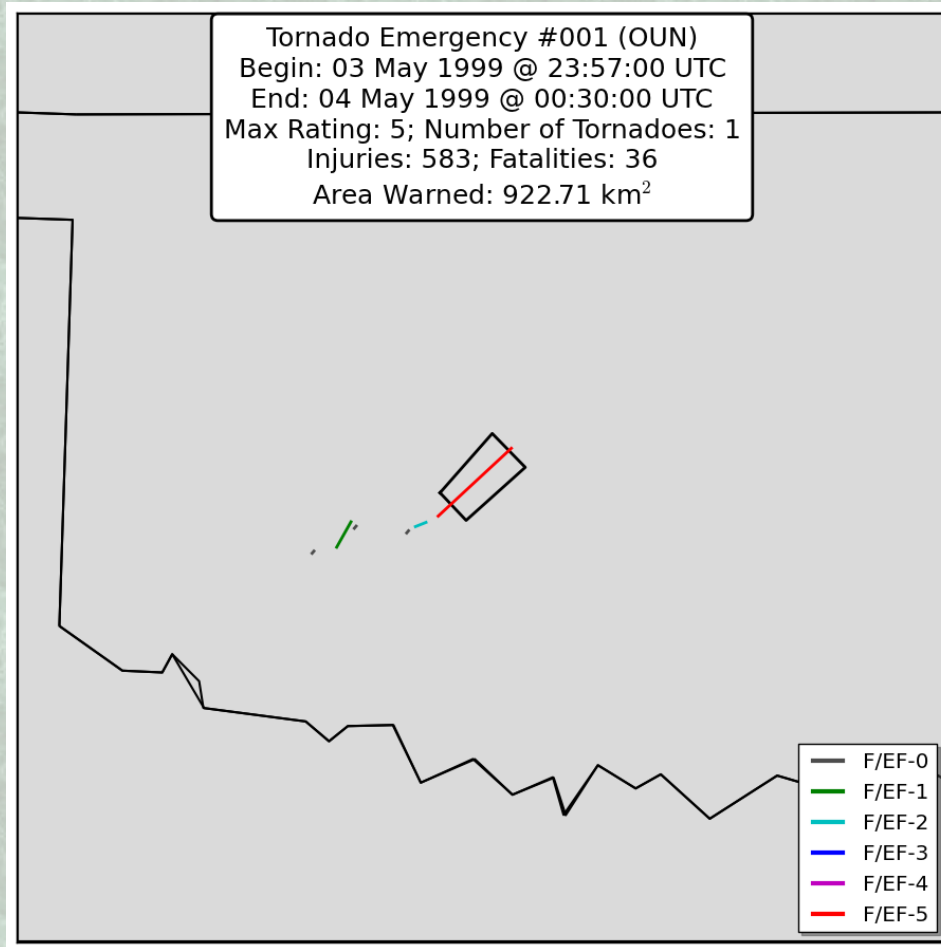
Number of Tornado Emergencies

5  
4  
3  
2  
1

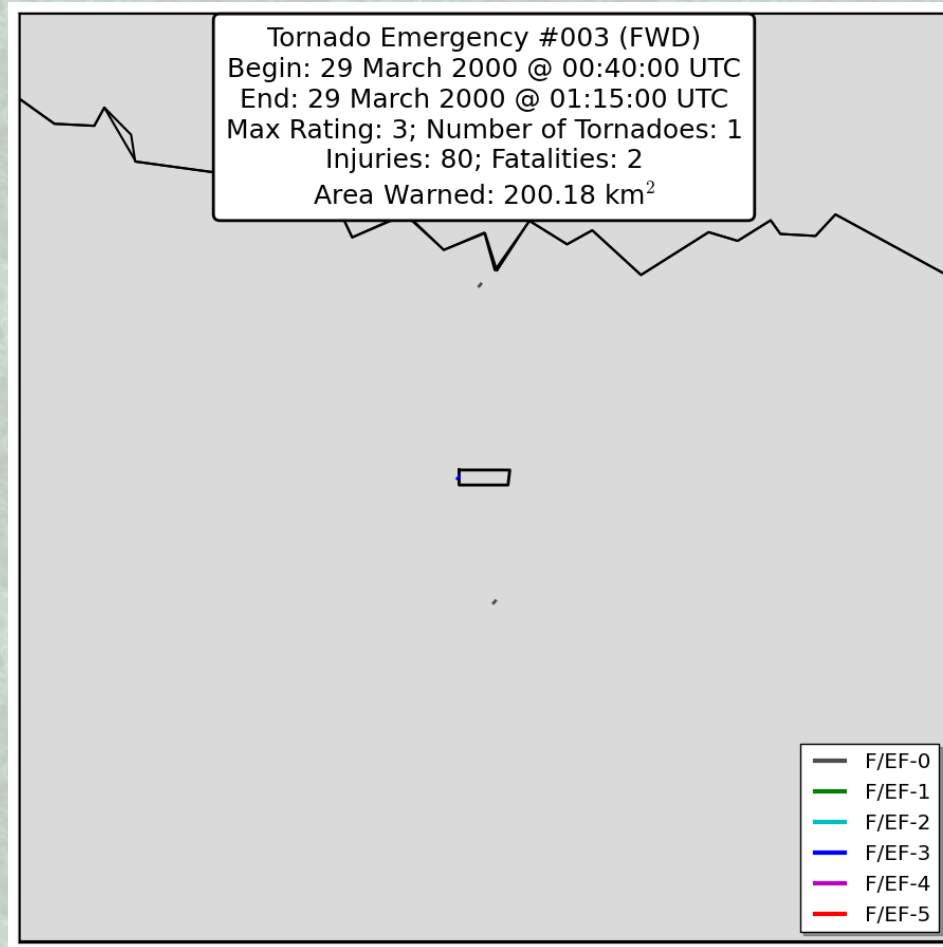
Gridded Tornado Emergencies  
1999-2011



# The First

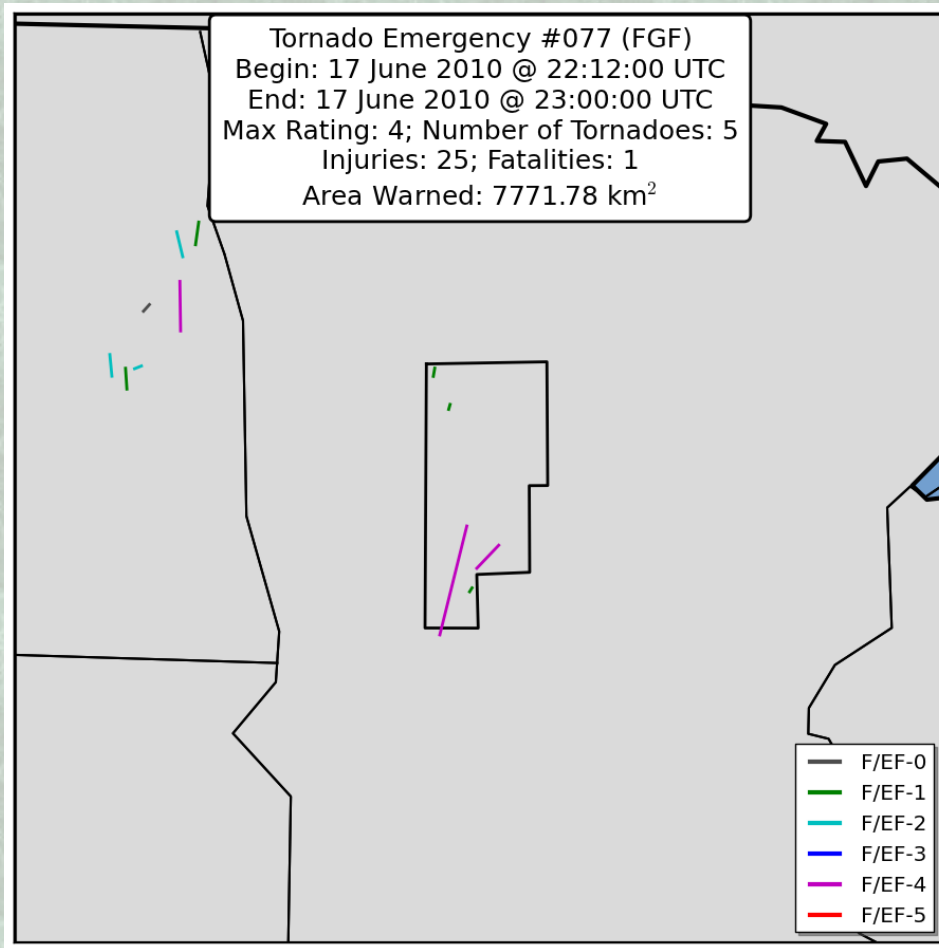


# The Smallest (200.18 km<sup>2</sup>)

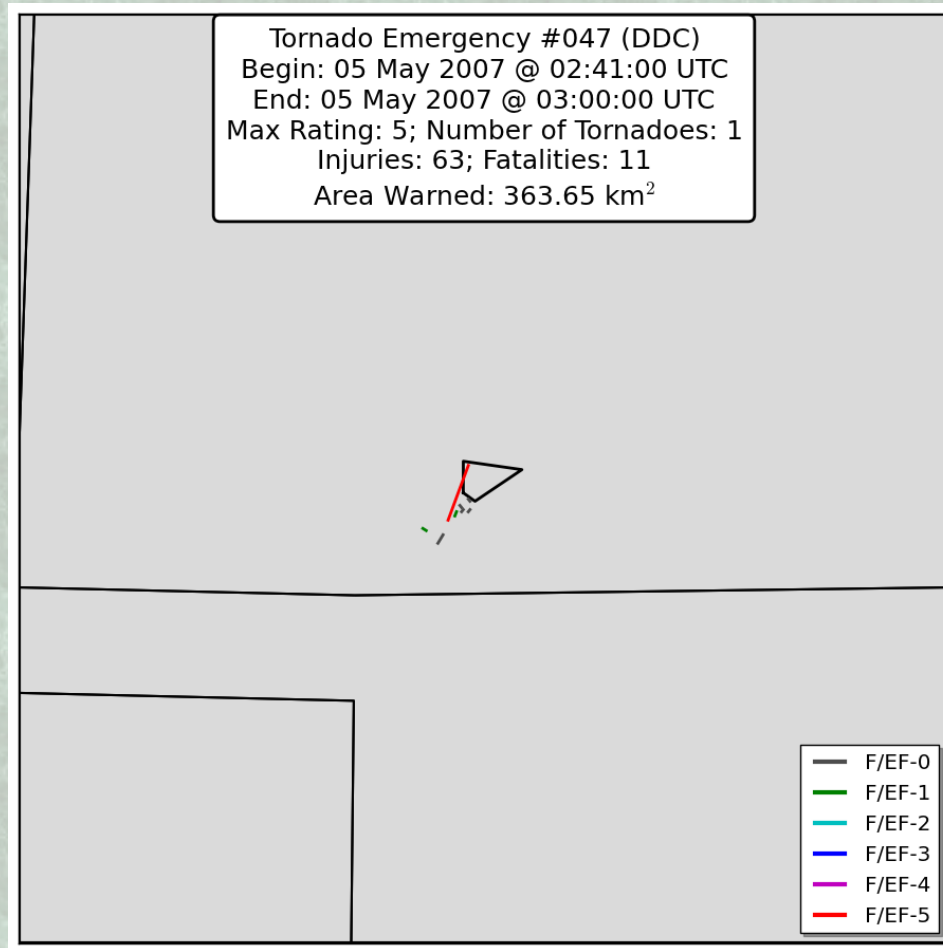




# The Largest (7771.78 km<sup>2</sup>)

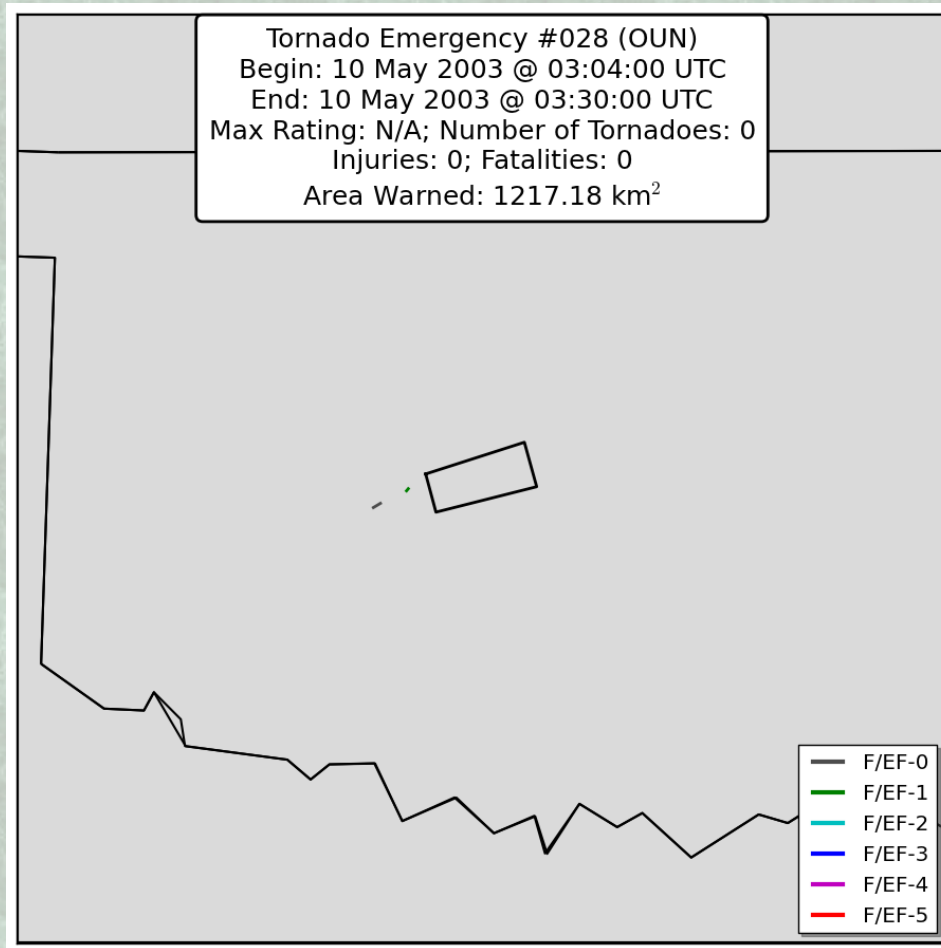


# The One Most People Remember (Greensburg, KS)



# A Miss!

## (Sort of...)



# Verification

- Tornadoes taken from SPC Database  
<http://www.spc.noaa.gov/wcm/#data>
- Tornado Dataset
  - Paths Represented By Straight Line
  - Tornado Start Time; No Tornado End Time
    - Tornado must occur within a variable time of **Tornado Emergency** issuance
    - Tornado must begin before **Tornado Emergency** ends



# Verification (1999-2010)

- Using any Tornado (F/EF0 – F/EF5)
  - SR: 71% (59 / 83)
  - FAR: 29% (24 / 83)

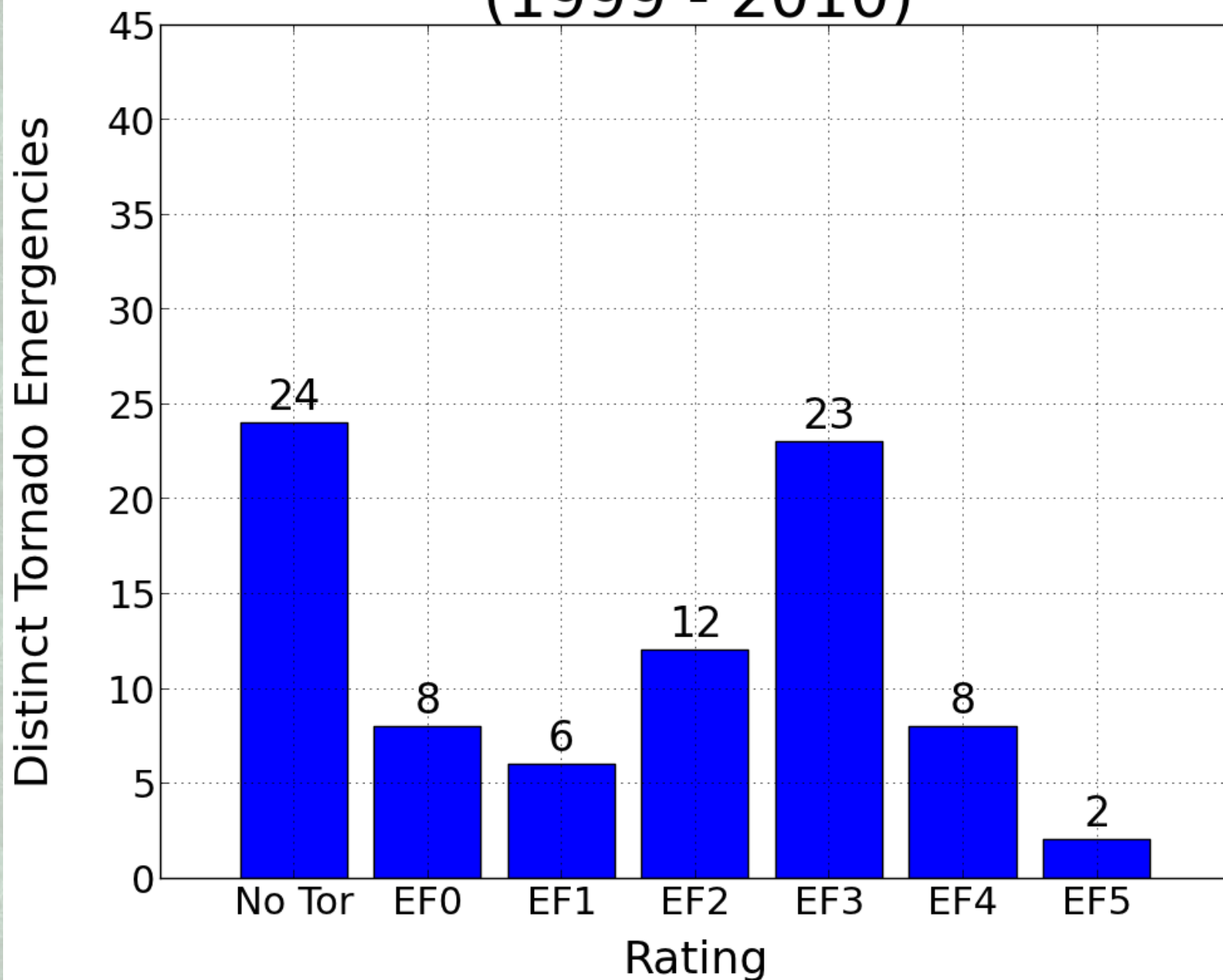
# Verification (1999-2010)

- Using any Tornado (F/EF0 – F/EF5)
  - SR: 71% (59 / 83)
  - FAR: 29% (24 / 83)
- Using Significant Tornadoes (F/EF2 – F/EF5)
  - SR: 54% (45 / 83)
  - FAR: 46% (38 / 83)

# Verification (1999-2010)

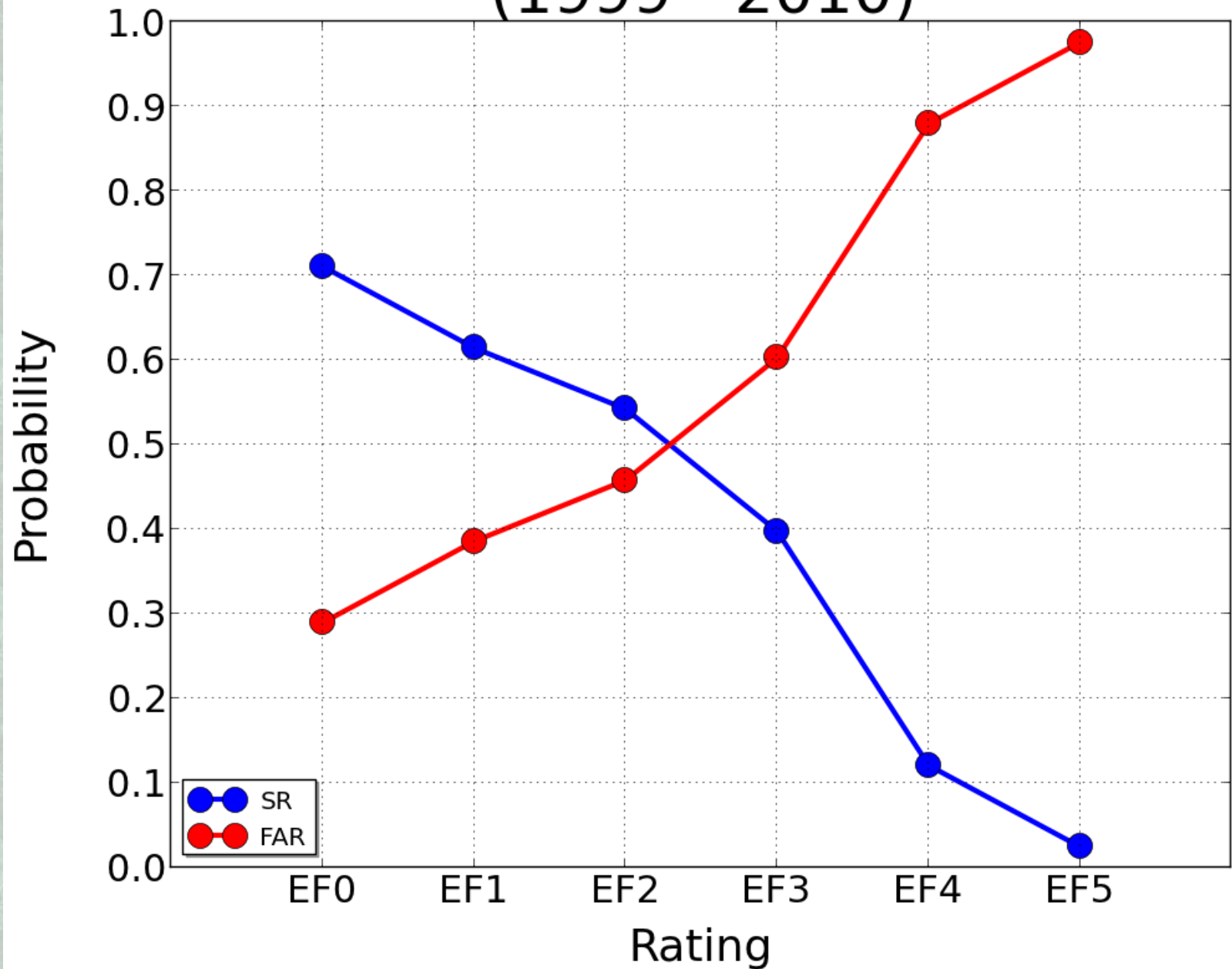
- Using any Tornado (F/EF0 – F/EF5)
  - SR: 71% (59 / 83)
  - FAR: 29% (24 / 83)
- Using Significant Tornadoes (F/EF2 – F/EF5)
  - SR: 54% (45 / 83)
  - FAR: 46% (38 / 83)
- Using Violent Tornadoes (F/EF4 – F/EF5)
  - SR: 12% (10 / 83)
  - FAR: 88 % (73 / 83)

# Tornado Emergencies by Rating (1999 - 2010)





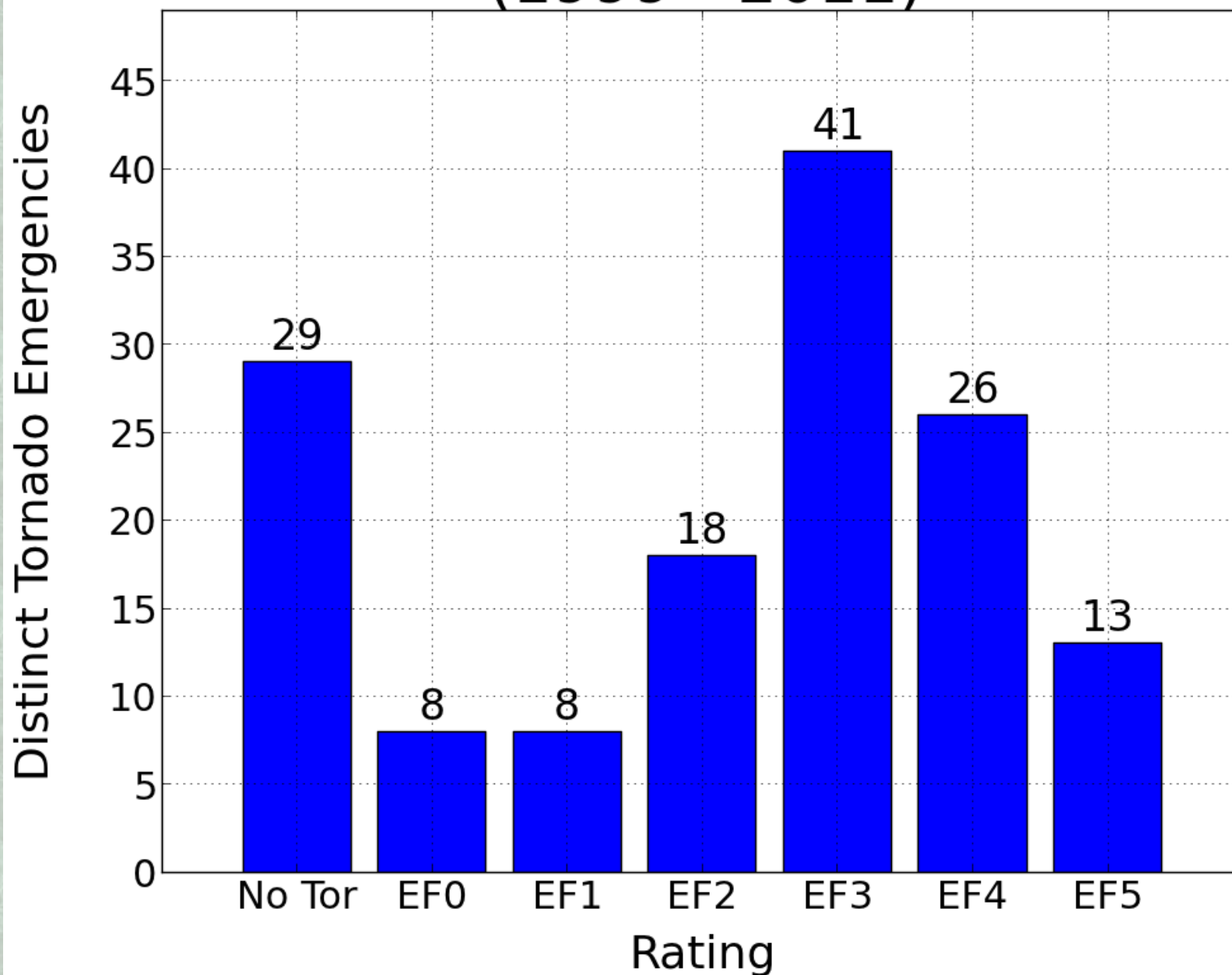
# Tornado Emergencies (1999 - 2010)



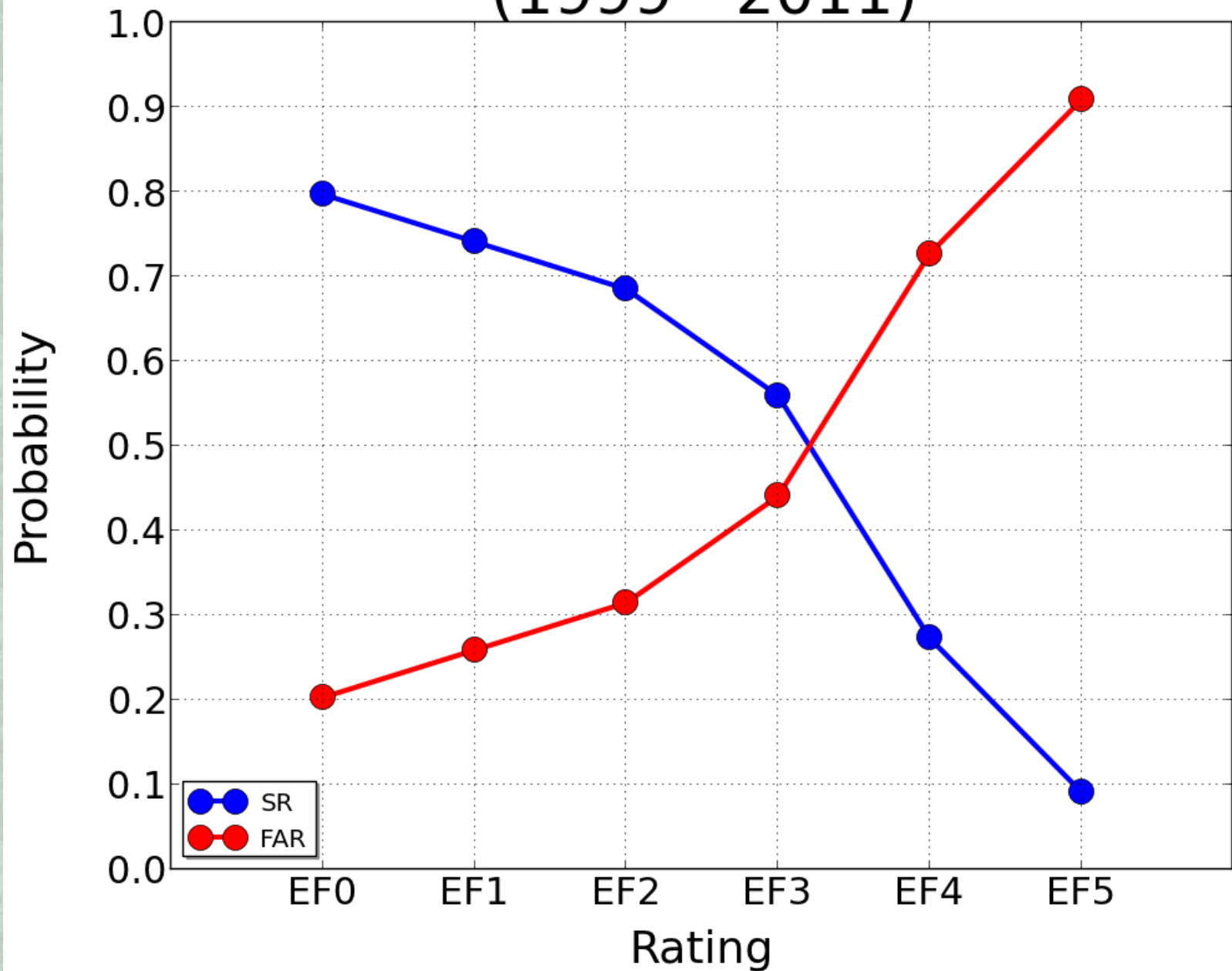
# Verification - 2011

- Using any Tornado (F/EF0 – F/EF5)
  - SR: 92% (55 / 60)
  - FAR: 8% (5 / 60)
- Using Significant Tornadoes (F/EF2 – F/EF5)
  - SR: 88% (53 / 60)
  - FAR: 12% (7 / 60)
- Using Violent Tornadoes (F/EF4 – F/EF5)
  - SR: 48% (29 / 60)
  - FAR: 52% (31 / 60)

# Tornado Emergencies by Rating (1999 - 2011)



# Tornado Emergencies (1999 - 2011)





# Verification – 2011

## (Sans 27-28 April)

- Using *any Tornado* (F/EF0 – F/EF5)
  - SR: 87% (20 / 23)
  - FAR: 13% (3 / 23)
- Using *Significant Tornadoes* (F/EF2 – F/EF5)
  - SR: 78% (18 / 23)
  - FAR: 22% (5 / 23)
- Using *Violent Tornadoes* (F/EF4 – F/EF5)
  - SR: 0% (0 / 23)
  - FAR: 100% (23 / 23)

**[16:10:19] <SKYWARN>**: I just heard a tornado emergency declaration on WAFF, have I missed an SVS/TOR notation?

**[16:10:20] <NWS>**: CC values showing large debris with second cell moving through Madison.

**[16:10:47] <NWS>**: Tornado on the ground...Moore's Mill and Lincoln Road. right now

**[16:11:34] <NWS>**: correction...eakin road...NOT lincoln road...

**[16:12:16] <NWS MIC>**: Wedge tornado likely moving through northern Madison county right now! CC values on KHTX indicative of very large debris.

**[16:13:12] <NATIONAL MEDIA>**: TORNADO EMERGENCY DECLARED OR NOT?

**[16:13:40] <MEDIA>**: Yes the emergency wording was in the SVS earlier

**[16:13:45] <SKYWARN>**: Thank you.

**[16:13:54] <NWS MIC>** YES!! Tornado emergency for that storm!

**[16:14:15] <NATIONAL MEDIA>**: what town

**SEVERE WEATHER STATEMENT  
NATIONAL WEATHER SERVICE WICHITA KS  
936 PM CDT SAT APR 14 2012**

**KSC191-150300-  
/O.CON.KICT.TO.W.0029.000000T0000Z-120415T0300Z/  
SUMNER KS-  
936 PM CDT SAT APR 14 2012**

**...A TORNADO WARNING REMAINS IN EFFECT FOR NORTHERN SUMNER COUNTY  
UNTIL 1000 PM CDT...**

**...TORNADO EMERGENCY FOR CONWAY SPRINGS...**

**AT 932 PM CDT...A CONFIRMED LARGE...VIOLENT AND EXTREMELY DANGEROUS  
TORNADO WAS LOCATED 5 MILES SOUTHWEST OF CONWAY SPRINGS...AND  
MOVING  
NORTHEAST AT 35 MPH.**

**THIS IS A PARTICULARLY DANGEROUS SITUATION.**

**HAZARD...DEADLY TORNADO.**

**SOURCE...SPOTTER CONFIRMED TORNADO.**

**IMPACT...THIS IS A LIFE THREATENING SITUATION. YOU COULD BE KILLED IF  
NOT UNDERGROUND OR IN A TORNADO SHELTER. COMPLETE  
DESTRUCTION OF ENTIRE NEIGHBORHOODS IS LIKELY. MANY WELL  
BUILT HOMES AND BUSINESSES WILL BE COMPLETELY SWEEPED FROM  
THEIR FOUNDATIONS. DEBRIS WILL BLOCK MOST ROADWAYS. MASS  
DEVASTATION IS HIGHLY LIKELY MAKING THE AREA UNRECOGNIZABLE  
TO SURVIVORS.**

**SEVERE WEATHER STATEMENT  
NATIONAL WEATHER SERVICE WICHITA KS  
936 PM CDT SAT APR 14 2012**

**KSC191-150300-  
/O.CON.KICT.TO.W.0029.000000T0000Z-120415T0300Z/  
SUMNER KS-  
936 PM CDT SAT APR 14 2012**

**...A TORNADO WARNING REMAINS IN EFFECT FOR NORTHERN SUMNER COUNTY  
UNTIL 1000 PM CDT...**

**...TORNADO EMERGENCY FOR CONWAY SPRINGS...**

**AT 932 PM CDT...A CONFIRMED LARGE...VIOLENT AND EXTREMELY DANGEROUS  
TORNADO WAS LOCATED 5 MILES SOUTHWEST OF CONWAY SPRINGS...AND  
MOVING  
NORTHEAST AT 35 MPH.**

**THIS IS A PARTICULARLY DANGEROUS SITUATION.**

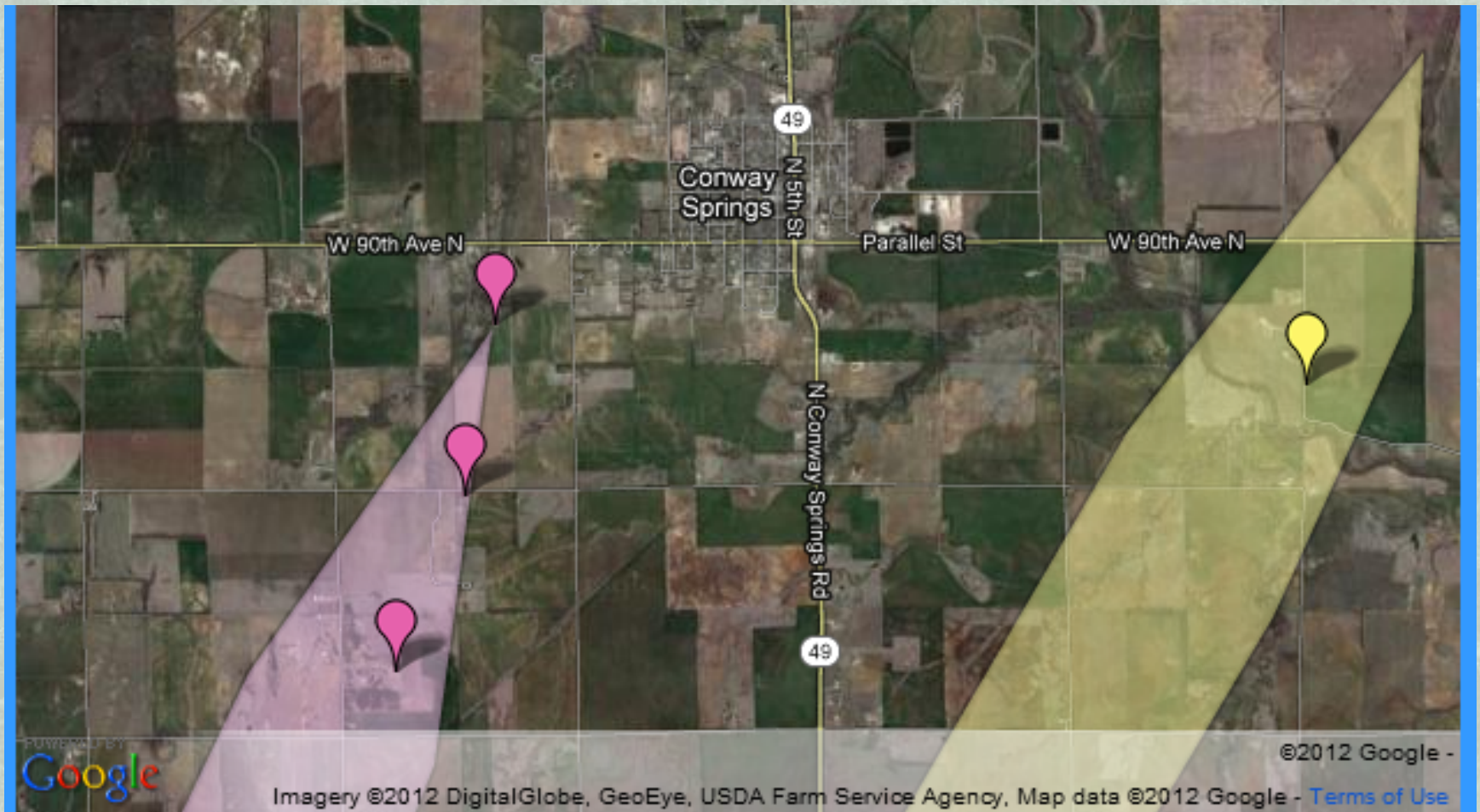
**HAZARD...DEADLY TORNADO.**

**SOURCE...SPOTTER CONFIRMED TORNADO.**

**IMPACT...THIS IS A LIFE THREATENING SITUATION. YOU COULD BE KILLED IF  
NOT UNDERGROUND OR IN A TORNADO SHELTER. COMPLETE  
DESTRUCTION OF ENTIRE NEIGHBORHOODS IS LIKELY. MANY WELL  
BUILT HOMES AND BUSINESSES WILL BE COMPLETELY SWEEPED FROM  
THEIR FOUNDATIONS. DEBRIS WILL BLOCK MOST ROADWAYS. MASS  
DEVASTATION IS HIGHLY LIKELY MAKING THE AREA UNRECOGNIZABLE  
TO SURVIVORS.**



# Conway Springs was Spared



# **What Will the Residents of Conway Springs Think Next Time?**

**Is the IBW Pilot Program Simply Delaying  
The Need to Address Underlying Issues  
Until A Later Date?**