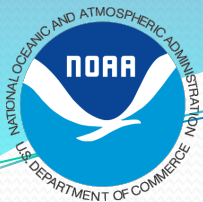


# The NWS Storm Prediction Center

## An Overview, and A Look At New Techniques

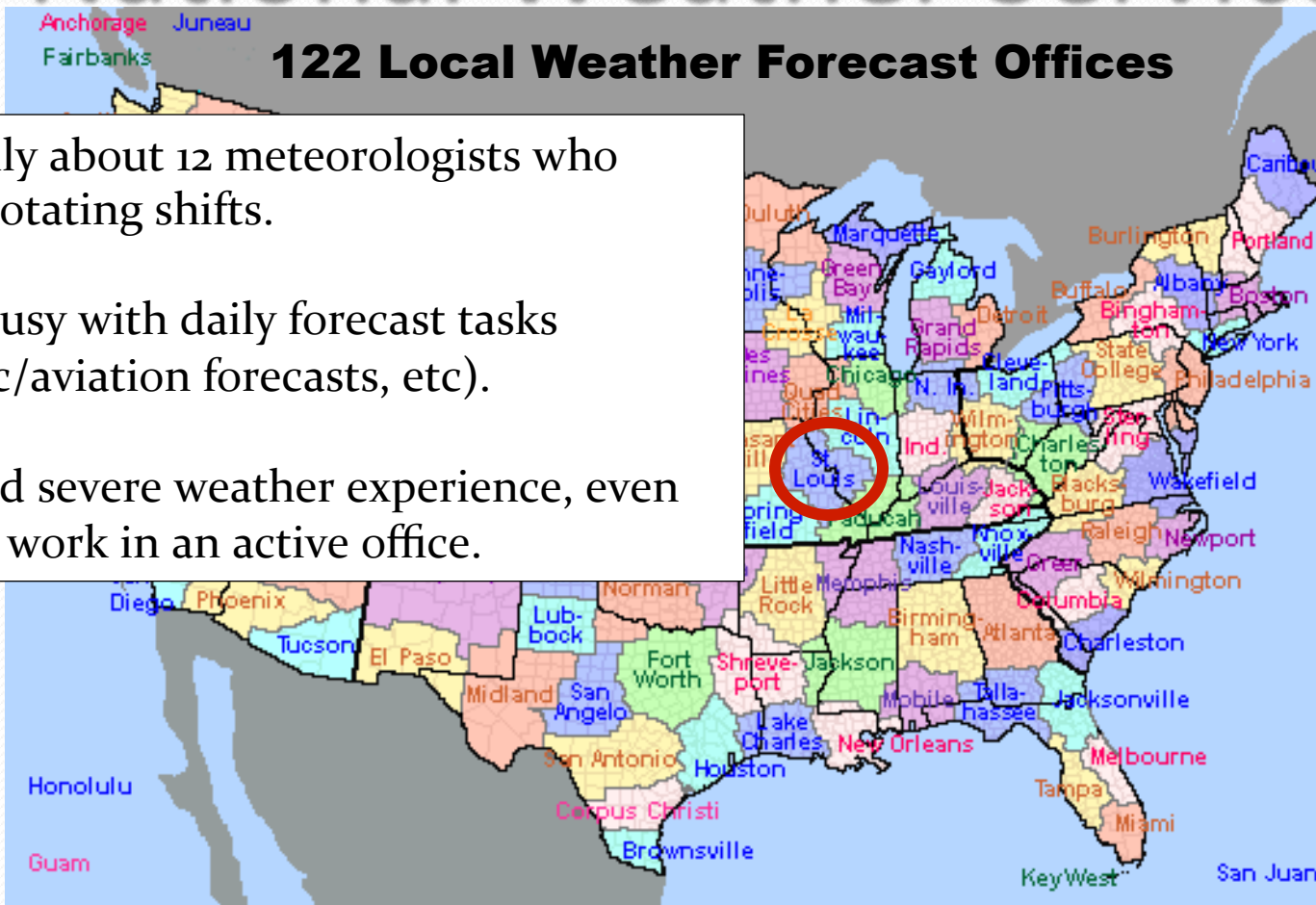
John Hart  
Storm Prediction Center, Norman, OK

7<sup>th</sup> European Conference on Severe Storms, Helsinki, Finland – Friday June 7<sup>th</sup>, 2013



SPC Overview:

# US National Weather Service



Usually about 12 meteorologists who work rotating shifts.

Very busy with daily forecast tasks (public/aviation forecasts, etc).

Limited severe weather experience, even if they work in an active office.

## SPC Overview:

# US Storm Prediction Center

- Focus on severe storms.
- Second set of eyes for the local offices.
- Consistent overview of severe storm threat.
- **HIGH EXPERIENCE LEVELS**
- **Very competitive to join staff**
  - **Stable staff**
  - **Few people leave before retirement**
- No competition with local offices
  - SPC does not issue warnings
  - Easy collaboration with local offices



Produced by the Dept. of Geography  
The University of Alabama

Our job is to help the local offices, not compete or overshadow.

## SPC Overview:

# US Storm Prediction Center

- Usually four forecasters on shift
  - Lead Forecaster
  - 2 mesoscale forecasters
  - 1 outlook forecaster
- **Lead Forecaster**
  - Shift supervisor
  - Makes final call on all products
  - Issues watches
  - Promoted from mesoscale/outlook forecaster ranks
- **Mesoscale Forecaster**
  - Focuses on 0-6 hour forecasts
  - Writes mesoscale discussions
- **Outlook Forecaster**
  - Focuses on longer ranges and larger scales
  - Days 1-8
  - Write convective outlooks



# My Background

- Career Forecaster
  - 25 years of operational experience
  - 23 years as forecaster at SPC
  - SPC Lead Forecaster for last 13 years
  - Also involved in software development



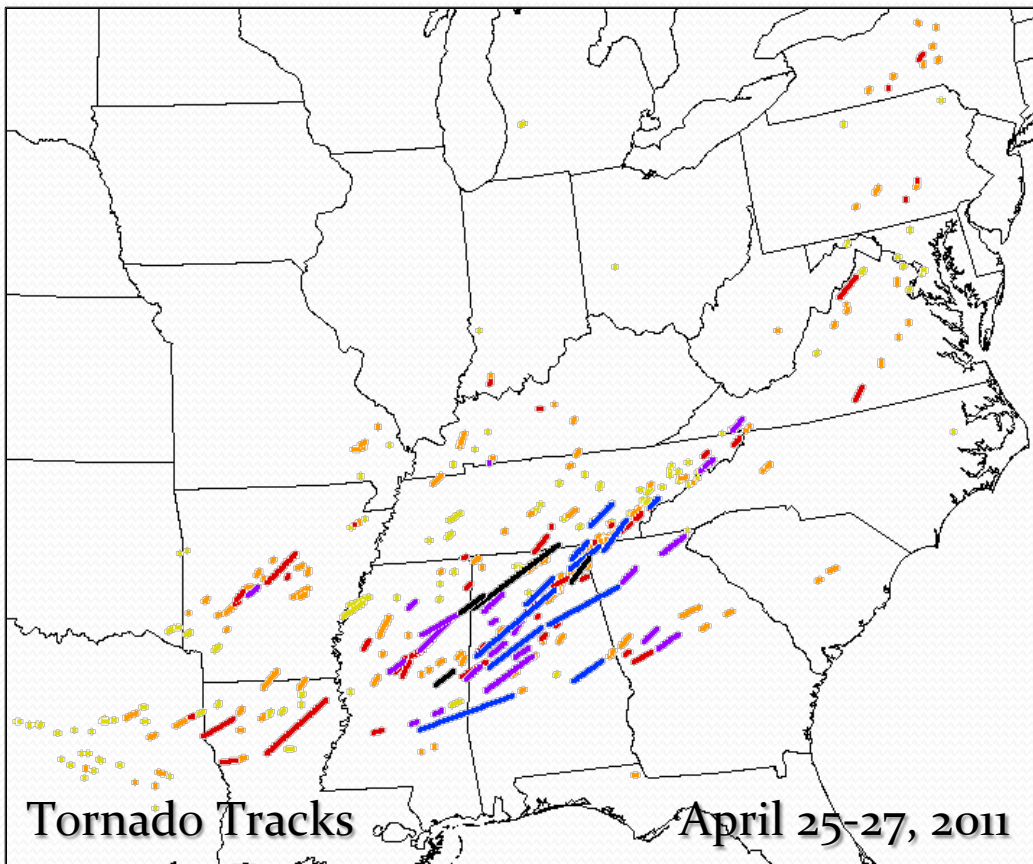
SPC forecasters typically have at least 10 years of specialized severe storms forecasting experience

# Large and Diverse Forecast Area



SPC Overview:

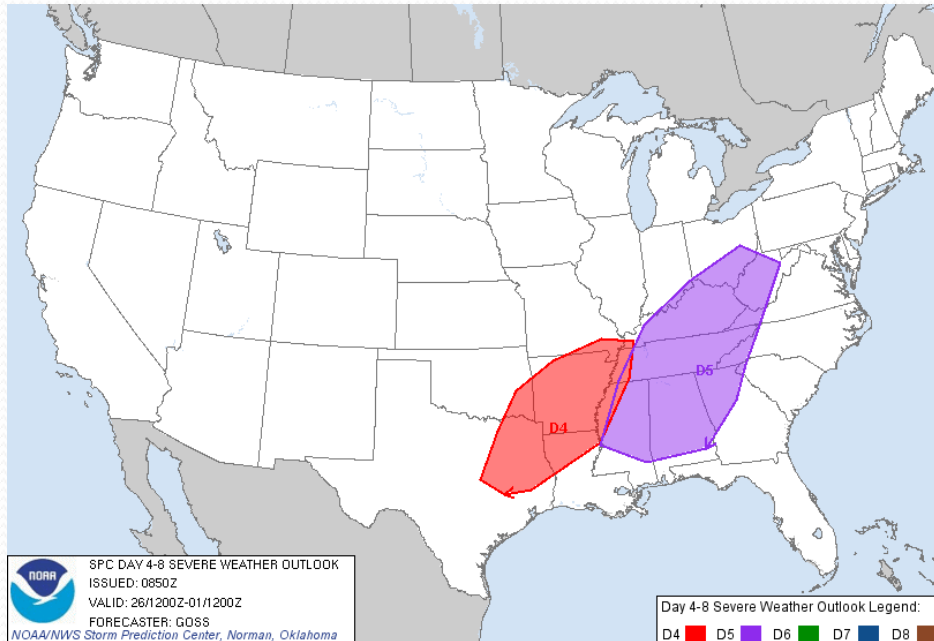
# April 27<sup>th</sup>, 2011 - OUTBREAK



- Largest tornado outbreak in over 30 years.
- 338 tornadoes in 3 days.
- A good example of the SPC mission in action.

SPC Overview:

# April 27<sup>th</sup>, 2011 - OUTBREAK

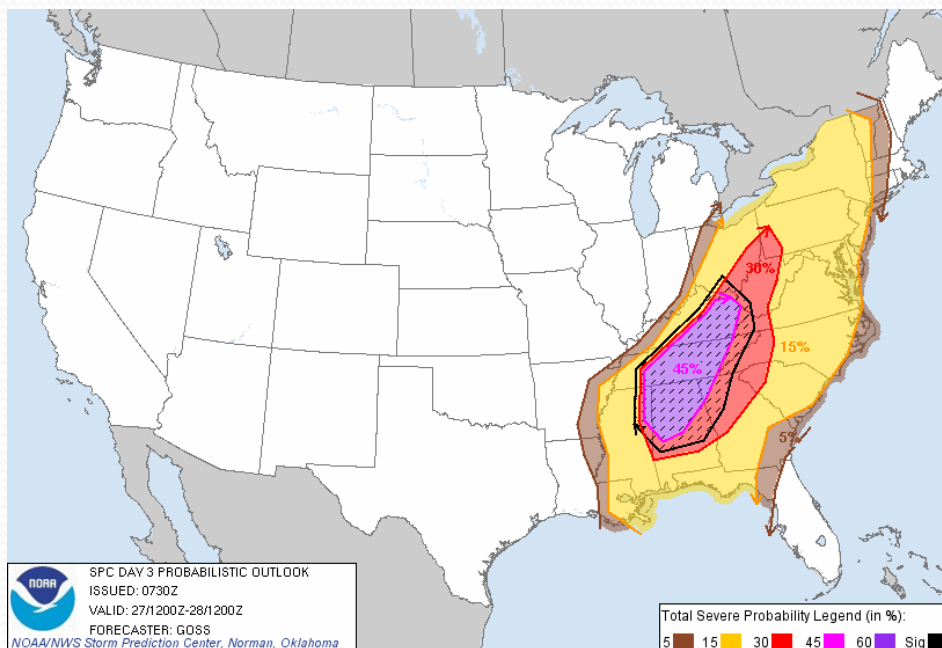


- Began issuing statements on potential 5 days before event.
- Day 5 Outlook:  
“AMPLY UNSTABLE AIRMASS COMBINED WITH THE STRENGTH OF THE UPPER SYSTEM AND ASSOCIATED FLOW FIELD SUGGEST WIDESPREAD SEVERE WEATHER CAN BE EXPECTED...INCLUDING THE POTENTIAL FOR TORNADOES.”



SPC Overview:

# April 27<sup>th</sup>, 2011 - OUTBREAK



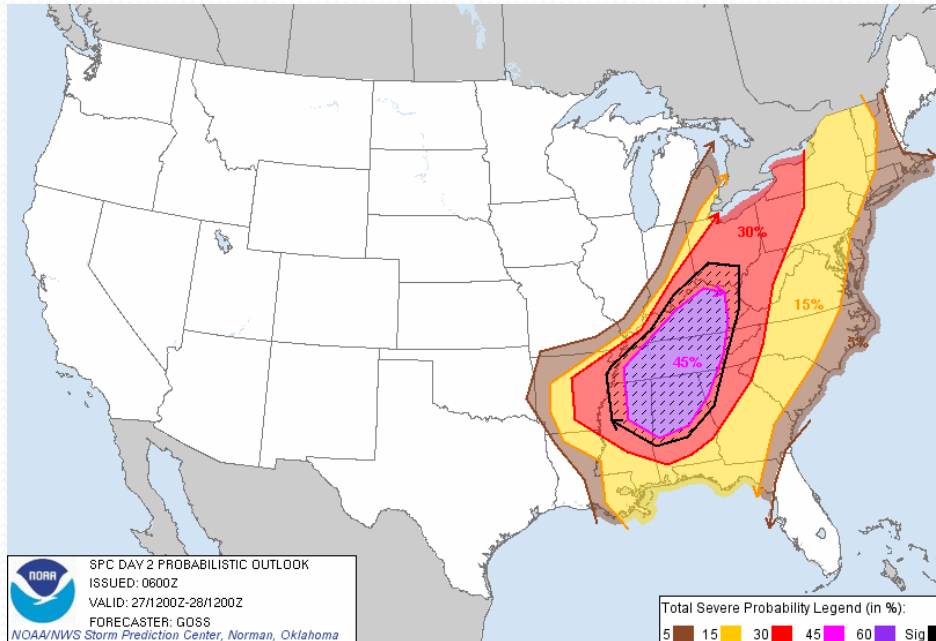
- Day 3 Outlook:

- MODERATE RISK

“YET ANOTHER DAY OF POTENTIALLY VERY SIGNIFICANT SEVERE WEATHER IS EXPECTED ... ELEVATED THREAT FOR A TORNADO OUTBREAK.”

## SPC Overview:

# April 27<sup>th</sup>, 2011 - OUTBREAK



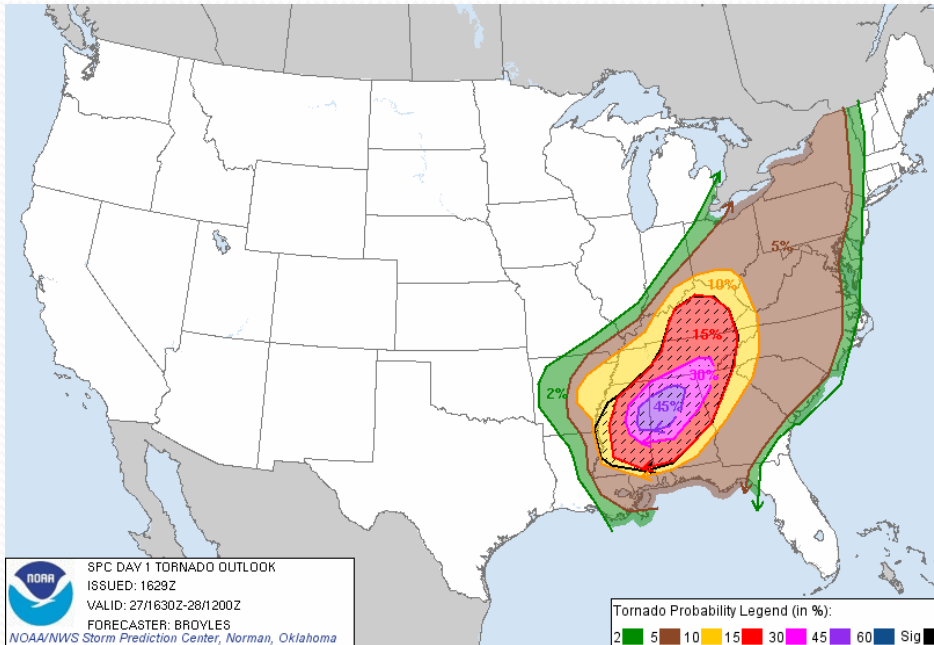
- Day 2 Outlook:

- MODERATE RISK

“POTENTIAL FOR A SIGNIFICANT/  
WIDESPREAD SEVERE WEATHER EVENT –  
INCLUDING THE POSSIBILITY OF A TORNADO  
OUTBREAK”

SPC Overview:

# April 27<sup>th</sup>, 2011 - OUTBREAK



- Day 1 Outlook:

- HIGH RISK

“CONFIDENCE IS HIGH REGARDING THE POTENTIAL FOR A MAJOR TORNADO OUTBREAK THIS AFTERNOON AND EVENING.

...A VIOLENT TORNADO OR TWO MAY OCCUR...”



## SPC Overview:

# April 27th 2011 - OUTBREAK

Surface Analysis

Satellite Analysis

Model Evaluation

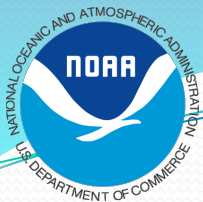
Sounding Analysis

A LONG LEAD-TIME/LONG DURATION PARTICULARLY DANGEROUS /PDS/ TORNADO WATCH WILL LIKELY BE ISSUED SOON...MOST CERTAIN ACROSS NORTHERN/CENTRAL PORTIONS OF MS.

VISIBLE SATELLITE/SURFACE OBSERVATIONAL TRENDS IMPLY RELATIVELY QUICK AIRMASS RECOVERY/ DESTABILIZATION IS OCCURRING FROM LA INTO MS/AL THROUGH MID/LATE MORNING. THIS IS THE CASE NOT ONLY FOR IN THE VICINITY OF EARLY MORNING WEST-EAST OUTFLOW ACROSS MS/AL...WHERE SURFACE TEMPERATURES/DEWPOINTS HAVE EACH INCREASED 8-12F OVER THE PAST 2 HR...BUT ALSO IN THE WAKE OF AN APPARENT WAVE-LIKE FEATURE SPREADING EASTWARD CROSS CENTRAL PORTIONS OF MS/LA AS A CU FIELD OTHERWISE CONTINUES TO INCREASE/MATURE ACROSS NORTHEAST LA.

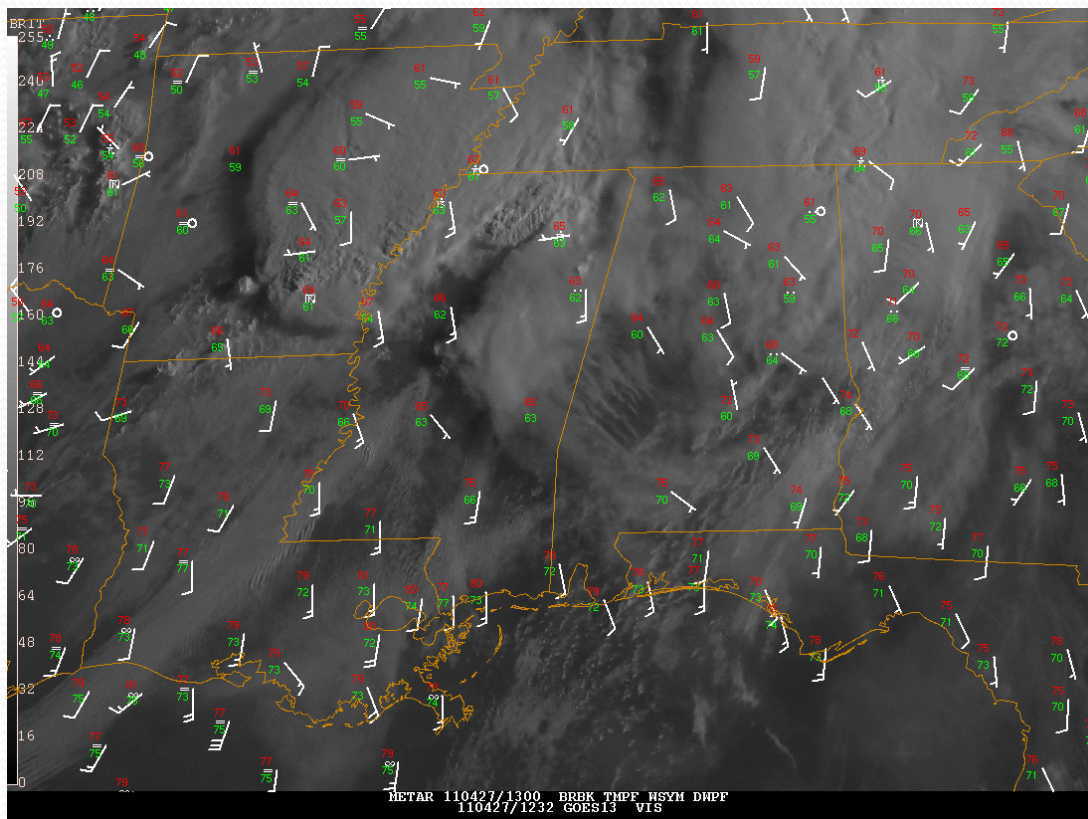
AIDED BY STRONG AMPLIFICATION/INTENSIFICATION OF AN INCREASINGLY NEGATIVE TILT SHORTWAVE TROUGH/ASSOCIATED JET STREAK LATER TODAY...A VOLATILE SCENARIO IS EXPECTED TO UNFOLD THROUGH THE AFTERNOON. CONVECTIVE INITIATION OF VIGOROUS CONVECTION BY EARLY/MID AFTERNOON IS WELL SUPPORTED BY EXPERIMENTAL GUIDANCE SUCH AS SEVERAL RECENT HRRR RUNS AND THE 12Z WRF-NMM. SHORT TERM FORECAST SOUNDINGS FROM GUIDANCE SUCH AS THE RUC/12Z NAM...ACCENTUATED BY VERY LONG/STRONGLY CURVED LOW LEVEL HODOGRAPHS...SUPPORT THE NOTION OF SUPERCELLS CAPABLE OF STRONG/POTENTIALLY VIOLENT TORNADOES THIS AFTERNOON/EARLY EVENING ESPECIALLY ACROSS THE HIGH RISK AREA.

**Attempt to write a confident forecast and show leadership**



SPC Overview:

# April 27<sup>th</sup>, 2011 - OUTBREAK

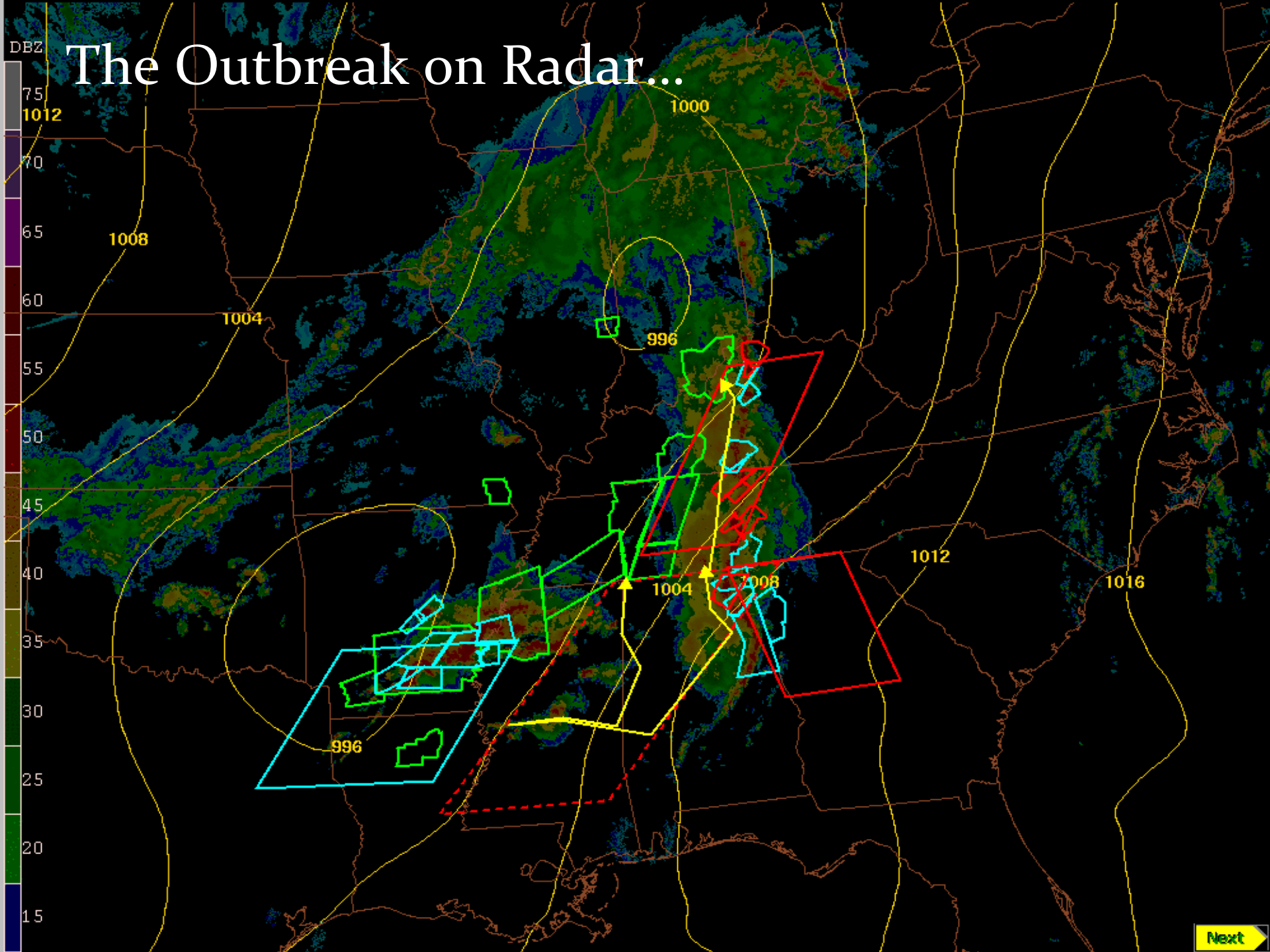


\* Mesoscale discussion issued at 1545 UTC.

\* Tornado watch issued at 1645 UTC.

\* Goal: Two-hour lead time  
Before first tornado.

# The Outbreak on Radar...



SPC Overview:

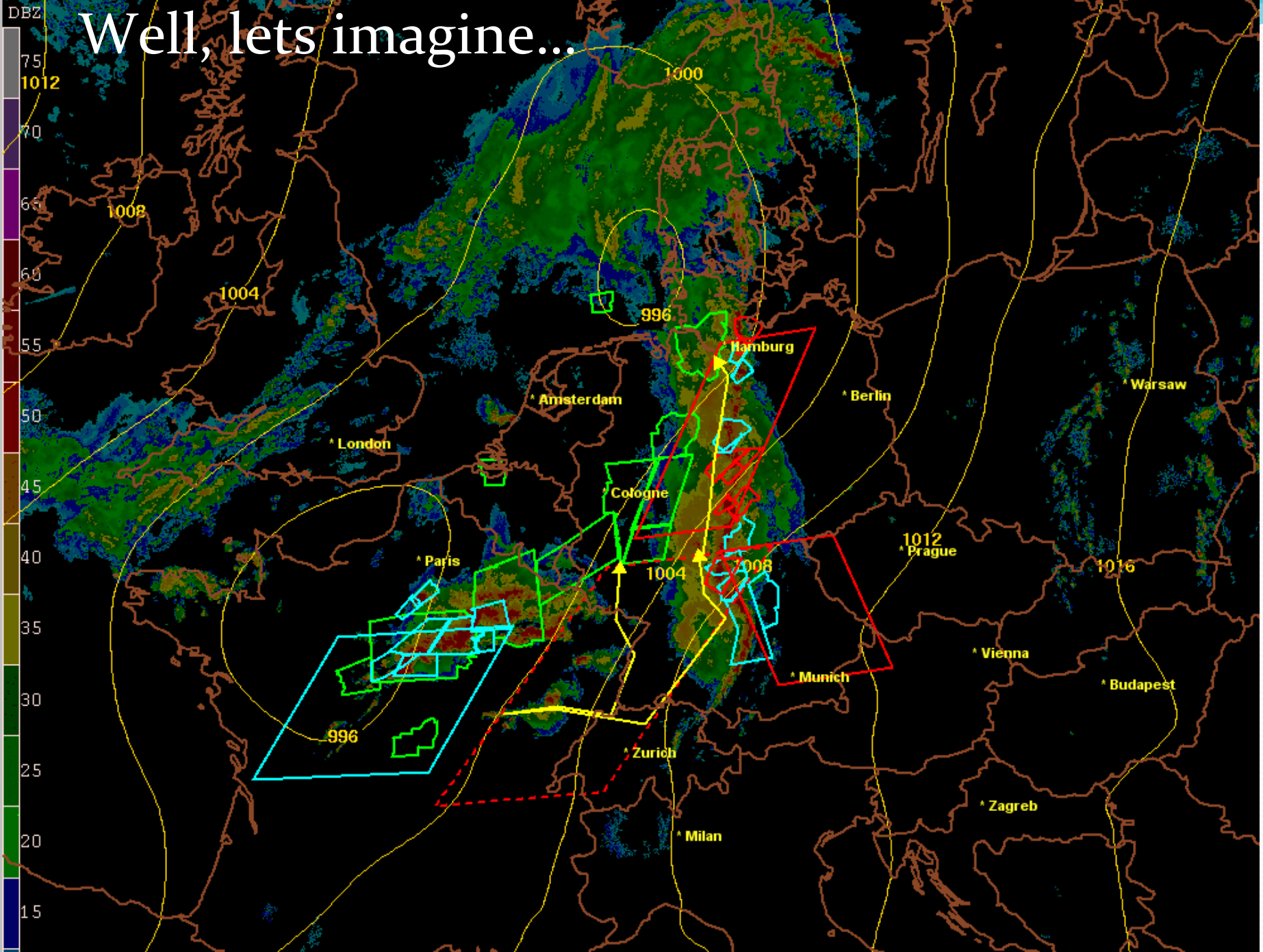
# April 27<sup>th</sup>, 2011 - OUTBREAK

What if...

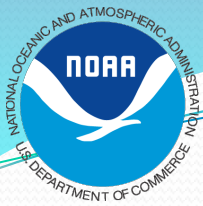
An event of this extent/magnitude occurred in *Europe*?



Well, lets imagine...







SPC Overview:

# Rare Event Forecasting



**Asymmetric Penalty Function!!!**

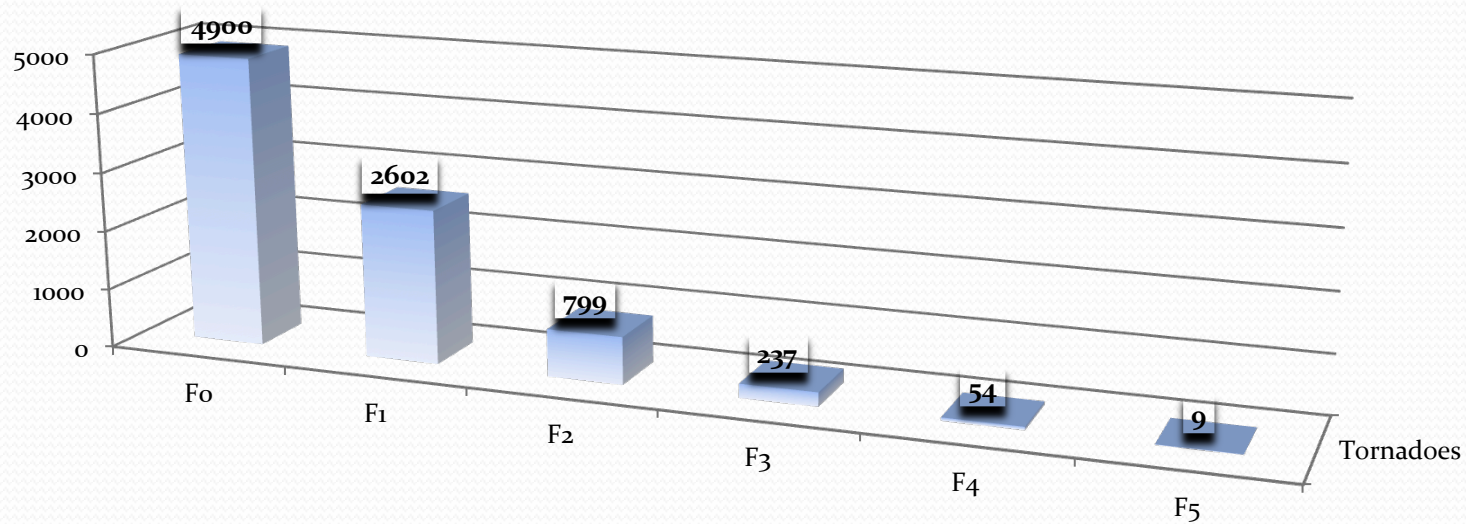
SPCs internal goal is to forecast the MOST LIKELY outcome. Sometimes we choose to lean toward the worst case scenario.



SPC Overview:

# Rare Event Forecasting

US Tornadoes (2007-2011)  
8,601 tornadoes

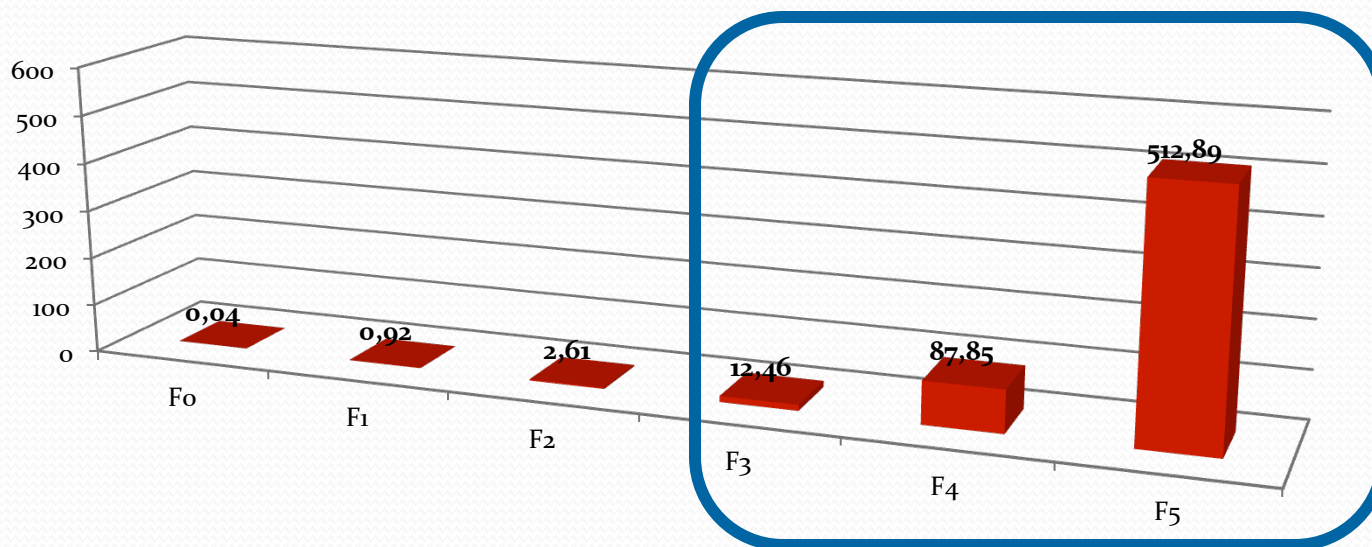




SPC Overview:

# Rare Event Forecasting

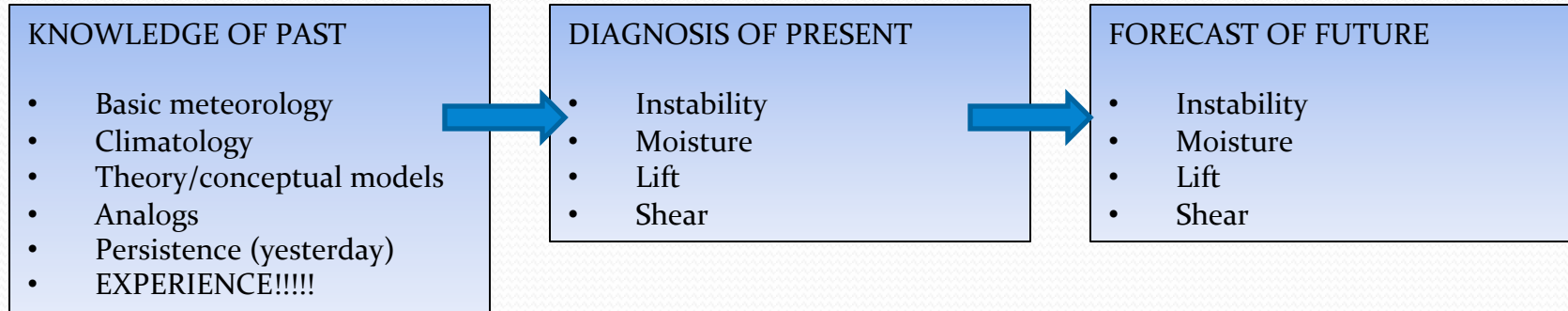
US Tornadoes (2007-2011)  
Cost per tornado (millions \$)



**3% of tornadoes result in 99% of damage!**

SPC Overview:

# Severe Thunderstorm Forecasting



Learned in school,  
from the literature, and  
from training.

Always extremely  
important.

Requires an investment  
of time before any  
forecasts are created.

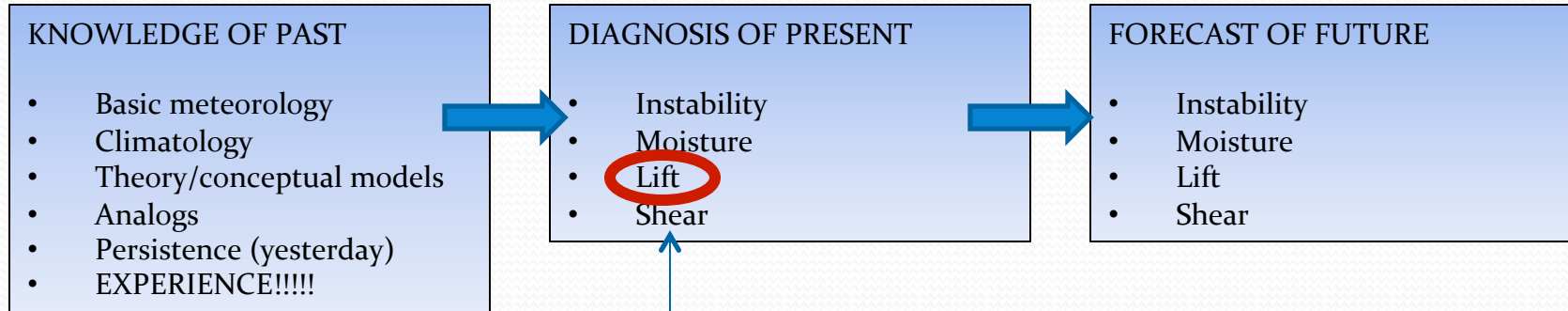
Most important for  
short-range forecasts.  
Less useful for longer-  
range forecasts.

Only possible after the  
first two items are satisfied.

Rarely if ever get it  
ALL right.

SPC Overview:

# Severe Thunderstorm Forecasting



**As an example,  
Let's examine just one element...**



SPC Overview:

# Severe Thunderstorm Forecasting

## Diagnosing Lift:

### Satellite

- Boundary layer
- Cumulus
- Gravity waves
- Shortwave
- Moistening
- Cooling
- Deepening
- High terrain convection
- Sea breeze interactions

### Other sources of information:

- Upper air chart analysis
  - Soundings
  - Radar
- Profilers / VAD Winds
- Derived analysis fields
  - Lightning data
  - Look outside
- The list goes on and on...

ur



ARLS System

Vaisala Lightning

Lightning Looper

Product Generation  
PC (web-based)



Forecaster

**Staggering amount of data!!  
Situational Awareness is vital!**

Analysis

**WHY DO WE LOOK FOR NEW METHODS?**

Hurricane  
Hotline

Dual-headed  
AWIPS  
(12Planet)

Dual-headed  
NAWIPS  
(each can load  
96 loops of  
15 frames)

GR Level 2/Level 3  
Radar Viewer

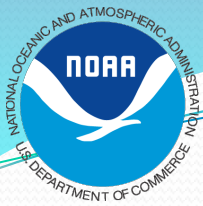
# Old Methods...

- Surface & upper air analysis
- Satellite
- Radar
- Model solutions for base fields
- Rules of thumb / climatology
- Science + Art (gut feelings)



**These remain ESSENTIAL to severe weather forecasting.**





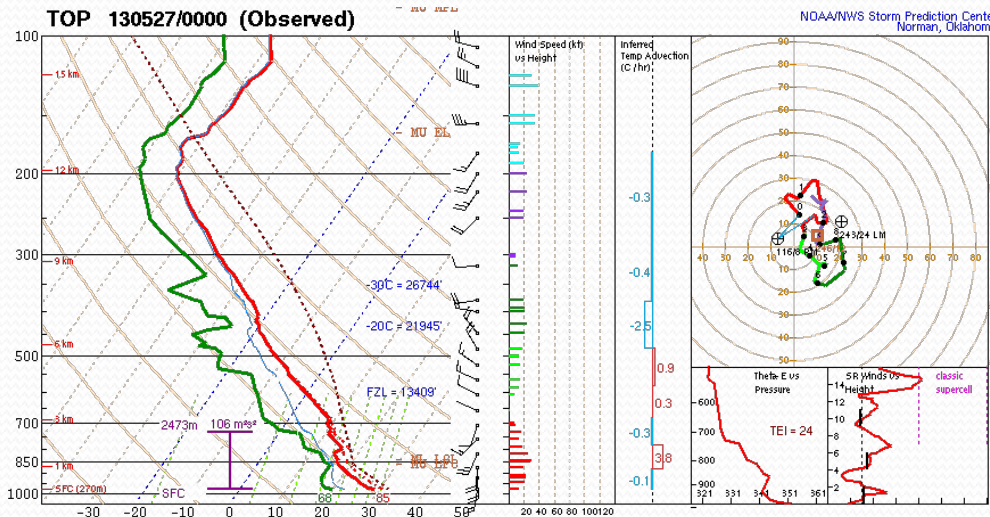
# New Methods...

## **\* IMPORTANT NOTE \***

**Virtually all forecast methods and tools provide probabilistic information.**

**There are very few “absolutes” in weather forecasting!!!**

# Its so much more than CAPE and Shear.



AT 941 PM CDT...A CONFIRMED LARGE AND EXTREMELY DANGEROUS TORNADO WAS LOCATED NEAR MARYSVILLE...AND MOVING EAST AT 40 MPH.

THIS IS A PARTICULARLY DANGEROUS SITUATION.

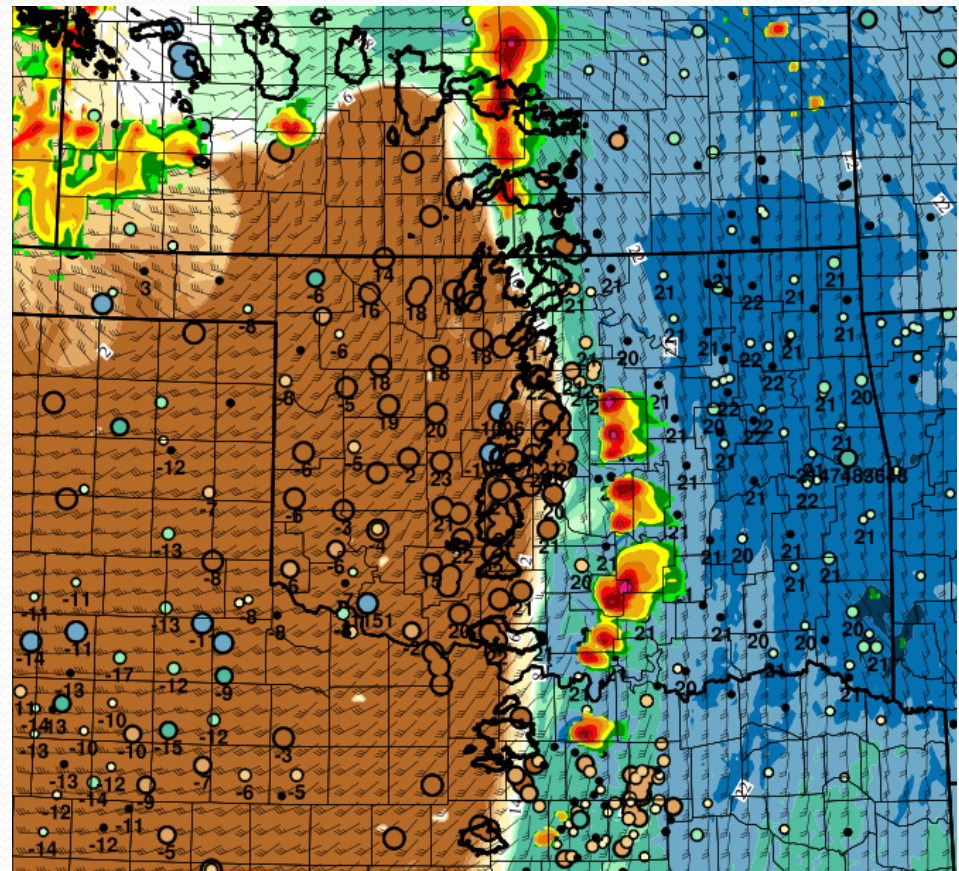
HAZARD...DAMAGING TORNADO.

SOURCE...EMERGENCY MANAGEMENT CONFIRMED TORNADO.

PARCEL	CAPE	CINH	LCL	LI	LFC	EL	SRH(m2/s2)	Shear(kt)	MnWind	SRW	*** BEST GUESS PRECIP TYPE ***	
SURFACE	3891	0	1143m	-10	1143m	43235'	SFC - 1 km	-5	8	177/20	200/18	Rain
MIXED LAYER	2276	-44	1314m	-7	2437m	42265'	SFC - 3 km	125	10	196/19	220/19	Based on sfc temperature of 84.6 F.
FCST SURFACE	2759	-14	1556m	-8	2224m	42691'	Eff Inflow Layer	106	7	194/20	216/20	SARS - Sounding Analogs
MU (980 mb)	3891	0	1143m	-10	1143m	43235'	SFC - 6 km		31	213/12	244/15	SUPERCELL
PW = 1.43 in	3CAPE = 2 J/kg	WBZ = 11030'	WINDG = 0.1				SFC - 8 km		19	224/11	252/15	SGFNT HAIL
K = 31	DCAPE = 1144 J/kg	FZL = 13409'	ESP = 0.0				Lower Half Storm Depth		32	218/11	248/15	89061300.A.MA 2.75
MidRH = 55%	DownT = 61 F	ConvT = 91F	MMP = 0.58				Cloud Bearing Layer		30	246/12	266/18	01071800.INL 2.75
LowRH = 65%	MeanW = 13.2 g/kg	MaxT = 86F					BRN Shear = 19 m/s²					No Quality Matches
SigSevere = 38105 m3/s3							4-6km SR Wind = 302/22 kt					
Sfc-3km Agl Lapse Rate = 7.5 C/km	<b>Supercell = 6.6</b>						.....Storm Motion Vectors.....					
3-6km Agl Lapse Rate = 8.3 C/km	<b>Left Supercell = 5.7</b>						Bunkers Flight = 116/8 kt					
850-500mb Lapse Rate = 7.2 C/km	<b>Sig Tor (CIN) = 0.6</b>						Bunkers Left = 243/24 kt					
700-500mb Lapse Rate = 8.1 C/km	<b>Sig Tor (fixed) = 0.0</b>						Corfidi Downshear = 313/29 kt					
	<b>Sig Hail = 1.9</b>						Corfidi Upshear = 336/23 kt					

# Storm-Resolving models

- Significant advancement for severe storms forecasting
- High detail can easily be taken literally (mistake)
- Any single SRM has limited benefit to forecasters for convection
- Capable of resolving “proxy” variables
- Common values we look for:
  - Updraft Helicity >  $25 \text{ m}^2/\text{s}^2$
  - Updraft Speed > 10 m/s
  - 10m Wind Speed > 30 knots
  - Reflectivity > 40 dBZ



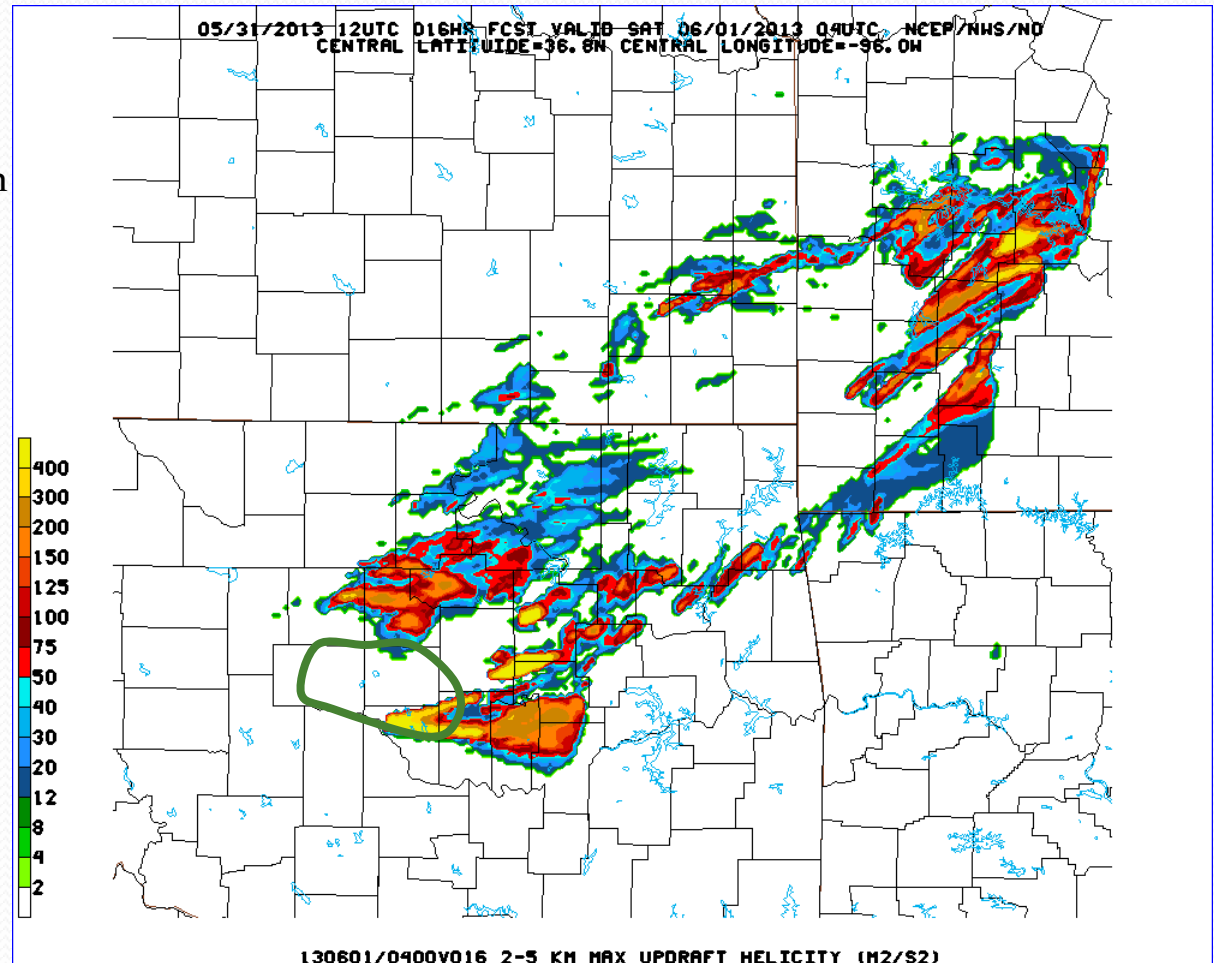
# Storm-Resolving models

- High detail can easily be taken literally (mistake)

**Wasn't that wonderful!**

**I wish it did that everyday  
But...it does not.**

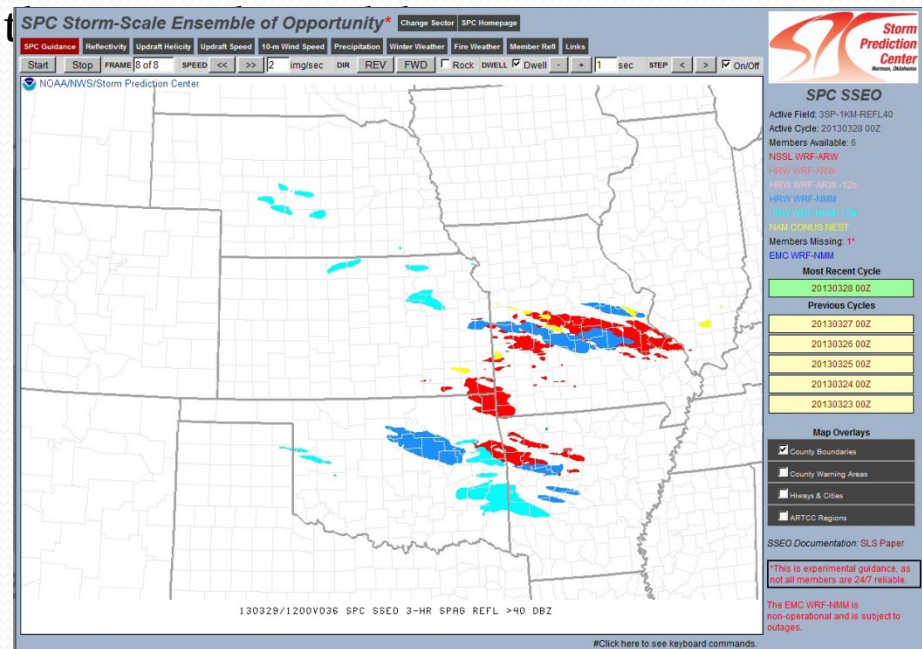
**How we know which day  
to believe any particular  
Storm-resolving model?**



# SSEO ( Storm-Scale Ensemble of Opportunity )

<http://www.spc.noaa.gov/exper/sseo>

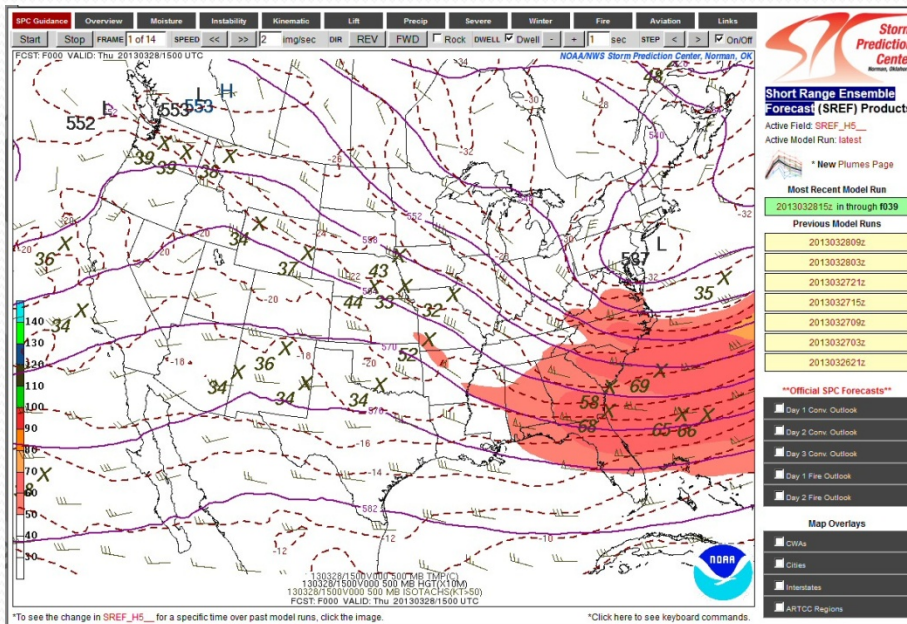
- Attempt to unify the output of several SRMs into a single source for forecasters.
- Output has been designed for rapid evaluation.
- System was created at SPC, for SPC forecasters.
- Proves to be much more credible than individual SRMs
  - NSSL 4km WRF-ARW
  - NWS 4km HRW-NMM
  - NWS 4km HRW-ARW
  - NWS 4km NMM-WRF
  - NWS NAM 4km NEST
- Time-lagged members
- Commonly used for mesoscale discussions and watches.



# SREF ( Short Range Ensemble Forecast )

<http://www.spc.noaa.gov/exper/sref>

- Post-processes all 21 members of the NCEP SREF
- Adds the 3-hour time lagged, operational WRF-NAM
- Total of 22 members
- Output has been designed for rapid evaluation.
- System was created at SPC, for SPC forecasters.
- Commonly used for outlooks.



# Convective Mode

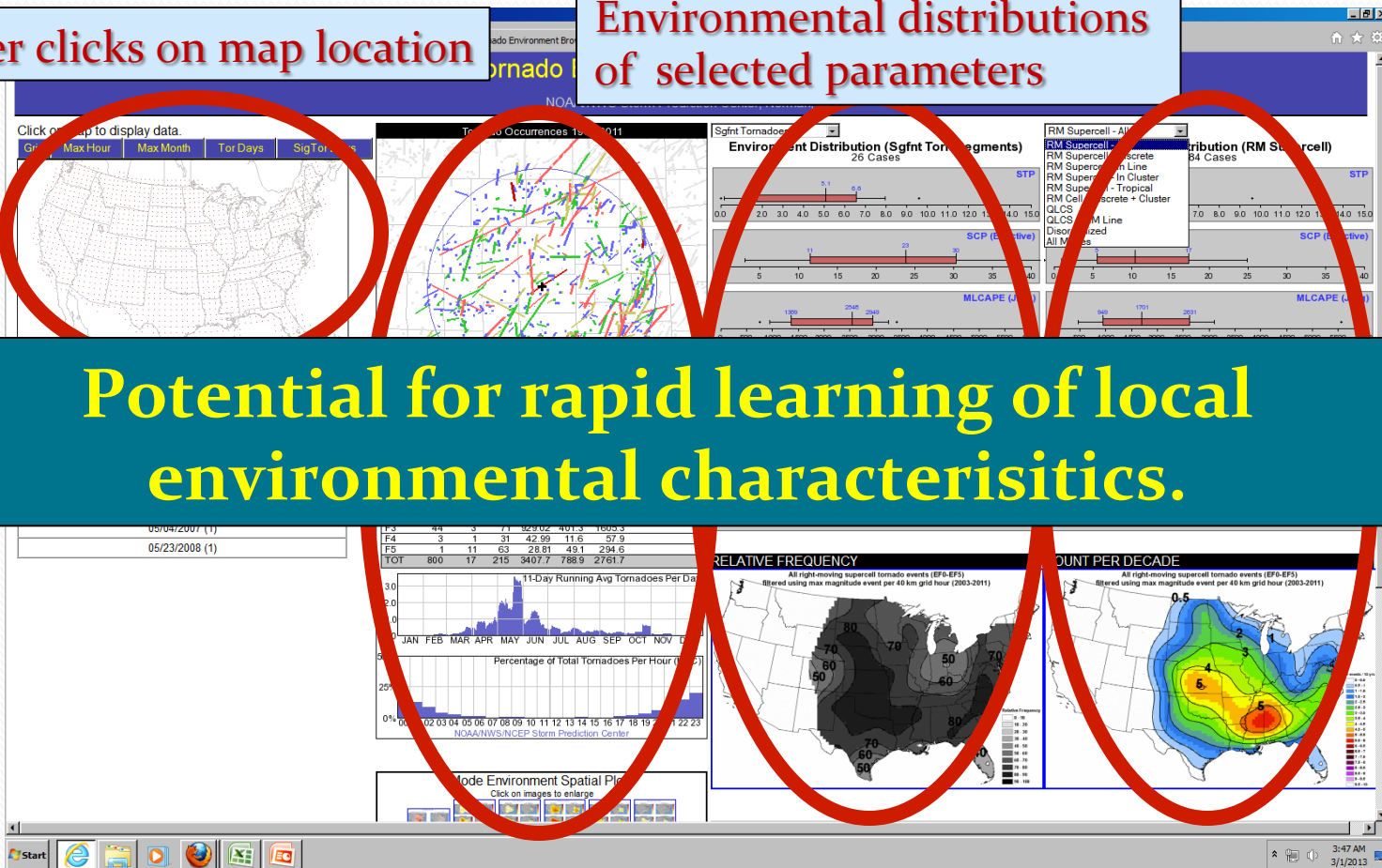
<http://www.noaa.gov/expert/envbrowser>

50 year tornado climatology

Parameter distributions by convective mode

User clicks on map location

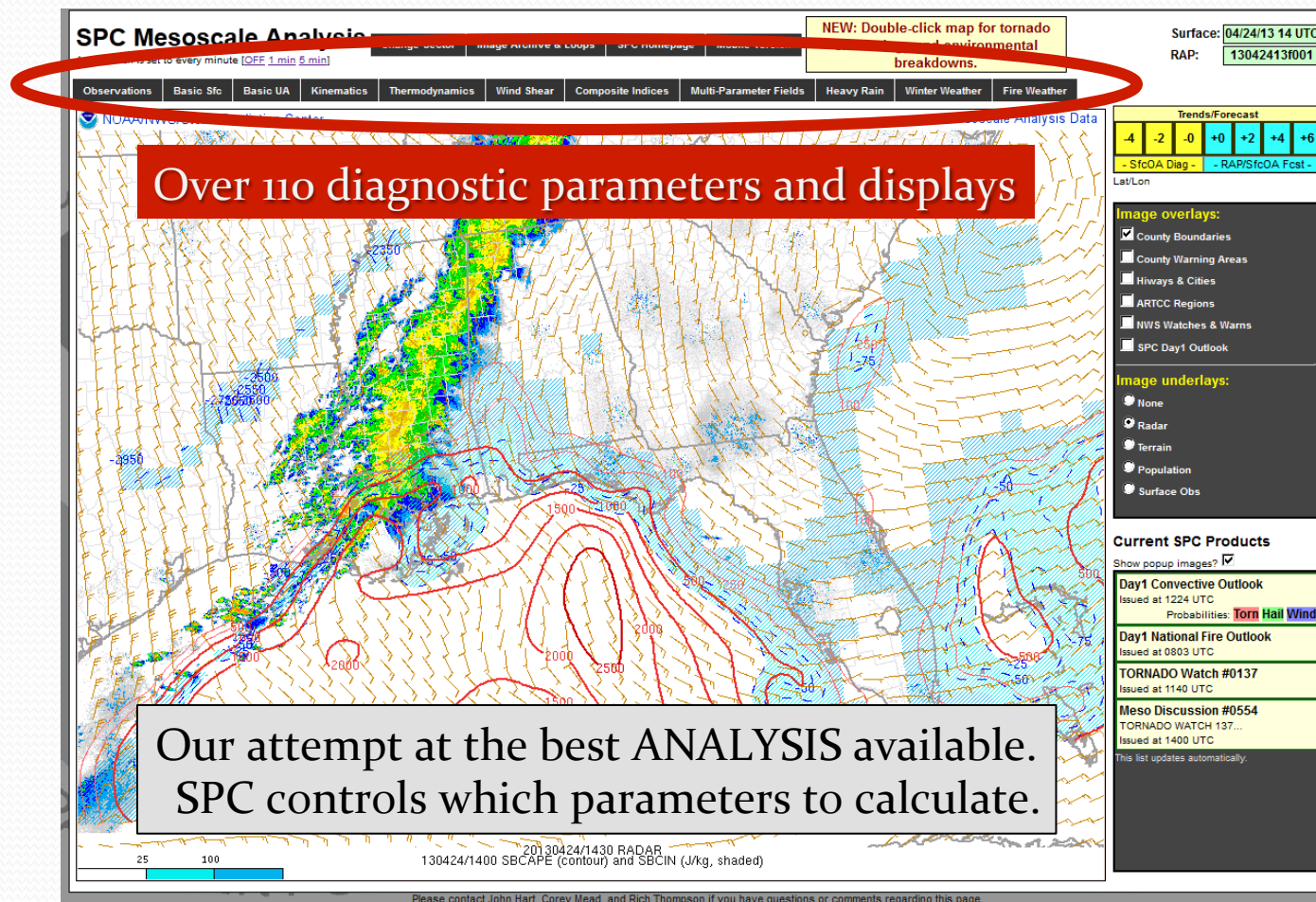
Environmental distributions of selected parameters



Potential for rapid learning of local environmental characteristics.

# Mesoanalysis Diagnostic Data

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



**NEW: Double-click map for tornado breakdowns.**

Surface: 04/24/13 14 UTC  
RAP: 13042413f001

Trends/Forecast  
-4 -2 0 +0 +2 +4 +6  
- SfcOA Diag - RAP/SfcOA Fcst -

Lat/Lon

**Image overlays:**

- County Boundaries
- County Warning Areas
- Highways & Cities
- ARTCC Regions
- NWS Watches & Warnings
- SPC Day1 Outlook

**Image underlays:**

- None
- Radar
- Terrain
- Population
- Surface Obs

**Current SPC Products**

Show popup images?

**Day1 Convective Outlook**  
Issued at 1224 UTC  
Probabilities **Torn Hail Wind**

**Day1 National Fire Outlook**  
Issued at 0803 UTC

**TORNADO Watch #0137**  
Issued at 1140 UTC

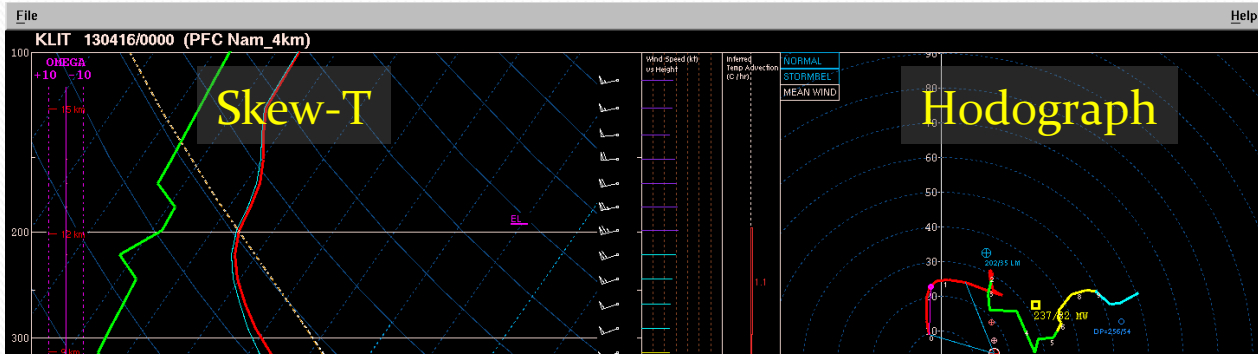
**Meso Discussion #0554**  
TORNADO WATCH 137...  
Issued at 1400 UTC  
This list updates automatically.

25 100  
20130424/1430 RADAR  
130424/1400 SBCAPE (contour) and SBCIN (M/kg, shaded)

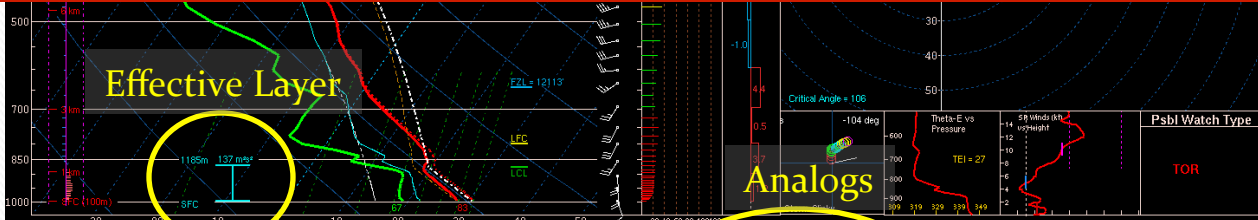
Please contact [John Hart](#), [Corey Mead](#), and [Rich Thompson](#) if you have questions or comments regarding this page.



# Observed and Forecast Soundings



Soundings analysis is extremely valuable for SPC



Parameters

CAPE	CIN	WZ	LFC	EL	SRH(m2/s2)	Shear(kt)	MnWind	SRW			
SB PARCEL	2710	-45	1131m	-8	1913m	40135	8FC - 1 km	183	16	172/21	133/25
ML PARCEL	2428	-38	1324m	-8	2072m	38803	8FC - 2 km	188	24	130/22	148/22
FCST SFC	2834	-4	1600m	-9	1913m	40135	8FC - 3 km	188	21	136/23	155/21
<b>MU PARCEL</b>	<b>2710</b>	<b>-45</b>	<b>1131m</b>	<b>-8</b>	<b>1913m</b>	<b>40135</b>	<b>Eff Inflow Layer</b>	<b>137</b>	<b>13</b>	<b>175/22</b>	<b>156/25</b>
EFF PARCEL	2307	-50	1389m	-7	2161m	38403	8FC - 8 km	38	38	214/23	187/16
USER DEF	55	-80	2937m	-0	3544m	24101	8FC - 9 km	44	44	219/24	179/15
							LCL - EL (Cloud Layer)	57	233/31	210/17	
							Lower limit Storm Depth	30	215/23	168/18	

SARS - Sounding Analog System		Effective Layer STP (with CIN)	
SUPERCELL	SCFNT HAIL	Prob SFC torn with supercell	
browse to -thompson / sep / snd / *	browse to -level / hail / snd / *	Sample CLIM0 = 15 sptor	
00062519 AID	NONTOR	05042200 SGP	4.25
01042123 PIA	NONTOR	01050700 SHV	3.65
03052001 AGM	NONTOR	31061500 BIS	2.75
03062119 APX	NONTOR	89060300 TOP	2.75
89072300 FAR	NONTOR	08042000 BMX	2.75
		04040500 CRP	2.75
		89053100 TDP	2.00
		00072300 LRF	2.00
		04062800 BIS	1.75
		00071500 IAD	1.75

SB-3km Agl Lapse Rate =	23 C / 8.2 C/km	Supercell =	7.1
3-6km Agl Lapse Rate =	31 C / 6.7 C/km	STP (CIN) =	1.0
850-500mb Lapse Rate =	31 C / 7.5 C/km	STP (fixed) =	1.0
700-500mb Lapse Rate =	18 C / 6.8 C/km	SHIP =	1.4

Parameters: PW = 1.15 in, 3CAPE = 67 J/kg, WZ2 = 8830, WMO = 0.4, K = 25, DCAPE = 1231 J/kg, FZL = 12113', ESP = 1.6, MidRH = 37%, DownT = 59 F, ConvT = 88F, MMP = 0.73, LowRH = 62%, MeanV = 13.5 g/kg, MaxT = 88F, NCAPE = 0.26

Corrida Downshear = 256/54 kt  
Corrida Upshear = 280/25 kt  
Bankers Right = 257/16 kt  
Bankers Left = 202/35 kt

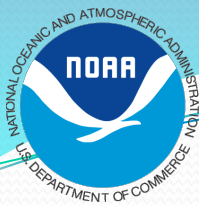
STPC (test) = 1.0

1km & 6km AGL Wind Barbs

Parcel Interpolate Swap Reset Overlay: off View Data SARS HAIL SHIP Stats STP Stats EBS Stats WINTER FIRE

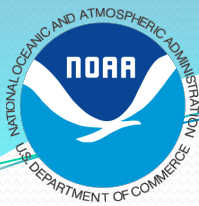
Surface conditions BMJ KF LEFT inset Boundary motion

Successfully loaded KLIT 130416/0000



# Other Newer Tools

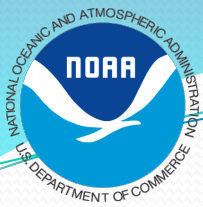
- Mesonets (high resolution observations)
- Increased spotter reports (web, near real-time)
- WDSS MESH (radar algorithm for hail)
- HailCast (cloud model for hail forecasting)
- Calibrated guidance (new methods in development)



# The Forecast Fringe...

- Shear vector orientation vs. boundary orientation
- Mid/high level storm-relative flow vector orientation
- Low level shear vector orientation “Critical Angle”
- High cape environment “bootstrapping”
- Near storm environment shear
- Veer-back vertical wind profile
- Upshear storm seeding/interference
- Recent outflow boundary effects
- A “cooked” outflow boundary
- Low level CAPE.
- Ambient vertical vorticity
- Supercell “short circuit” failures
- Storm competition
- Anvil shading
- Many others...

- Are we confident in the method?
- Can models confidently predict?
  
- The goal is to be right, not necessarily to test the bounds of our knowledge.
  
- **BUT WE ARE TRYING...**



# Wish List

- Powerful visualization systems
  - Efficiency is a priority!!!
- Larger Storm-Scale Ensembles
  - Diverse initializations
  - Diverse physics
- Observation Networks
  - More mesonets (surface)
  - VAD/Profilers (upper-air)
  - GOES-R (satellite)



# Conclusion

- Severe weather forecasting tests the limits of our science, but is a vital service in prone areas.
- New tools and methods are continuously becoming available. It's the forecaster's job to evaluate them and determine utility.
- Many of the visualization tools in use at SPC have been developed in-house. Visualization is under-appreciated!
- There is much left to learn and accomplish.
- ***Human experience is a powerful tool that will never be fully replaced by automation.***



# Thank You!

John Hart

National Weather Service  
Storm Prediction Center  
Norman, Oklahoma

[john.hart@noaa.gov](mailto:john.hart@noaa.gov)