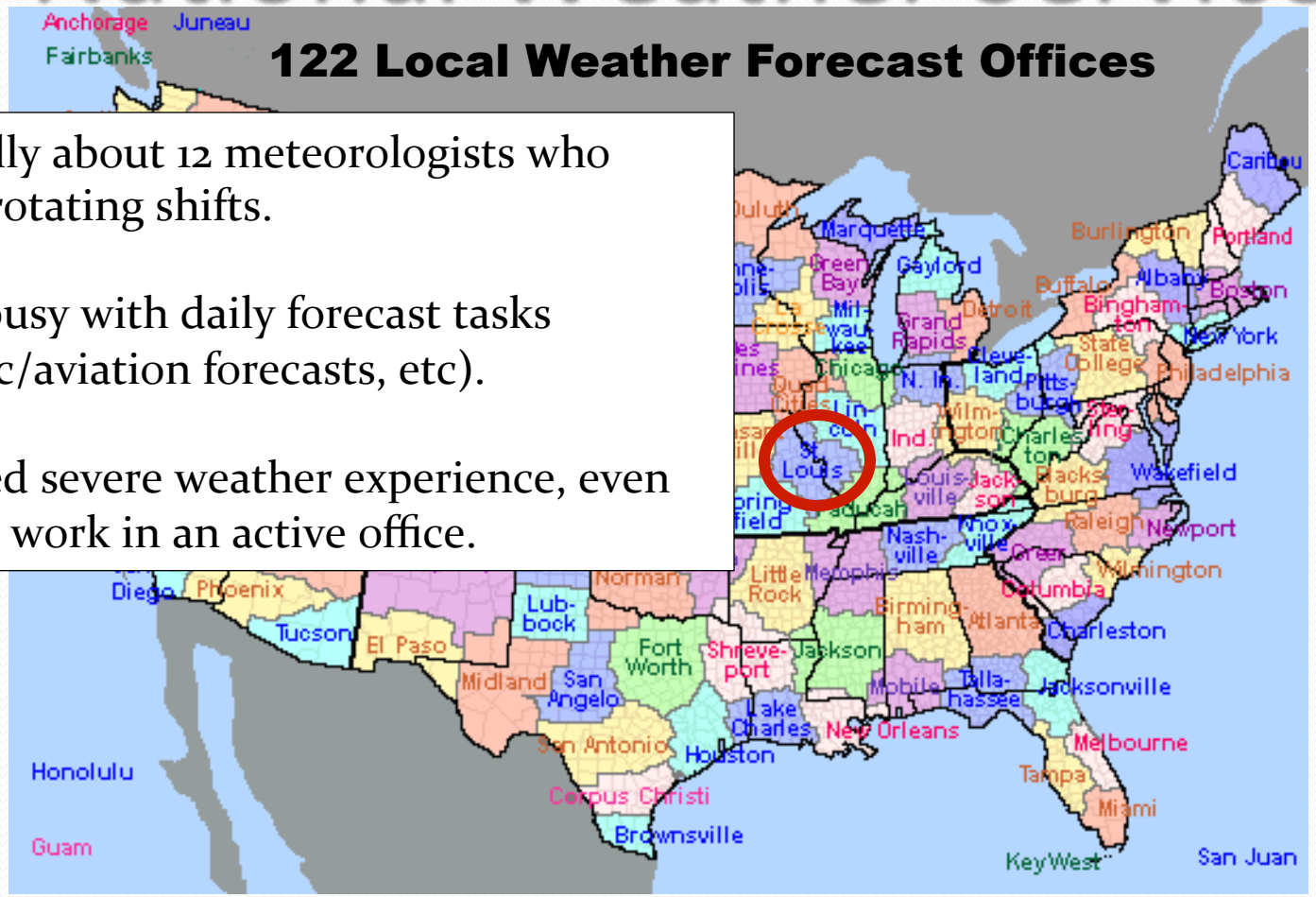
The NWS Storm Prediction Center
An Overview, and A Look At New Techniques

John Hart
Storm Prediction Center, Norman, OK

7th European Conference on Severe Storms, Helsinki, Finland – Friday June 7th, 2013

SPC Overview:

US National Weather Service



Ususally about 12 meteorologists who work rotating shifts.

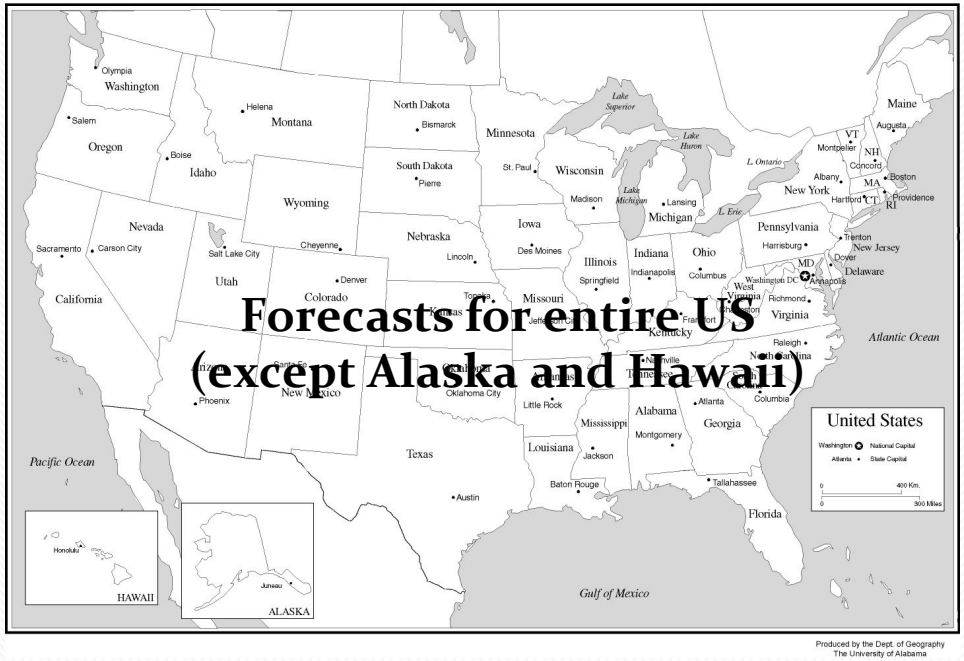
Very busy with daily forecast tasks (public/aviation forecasts, etc).

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



Our job is to <u>help</u> the local offices, not compete or overshadow.

SPC Overview:

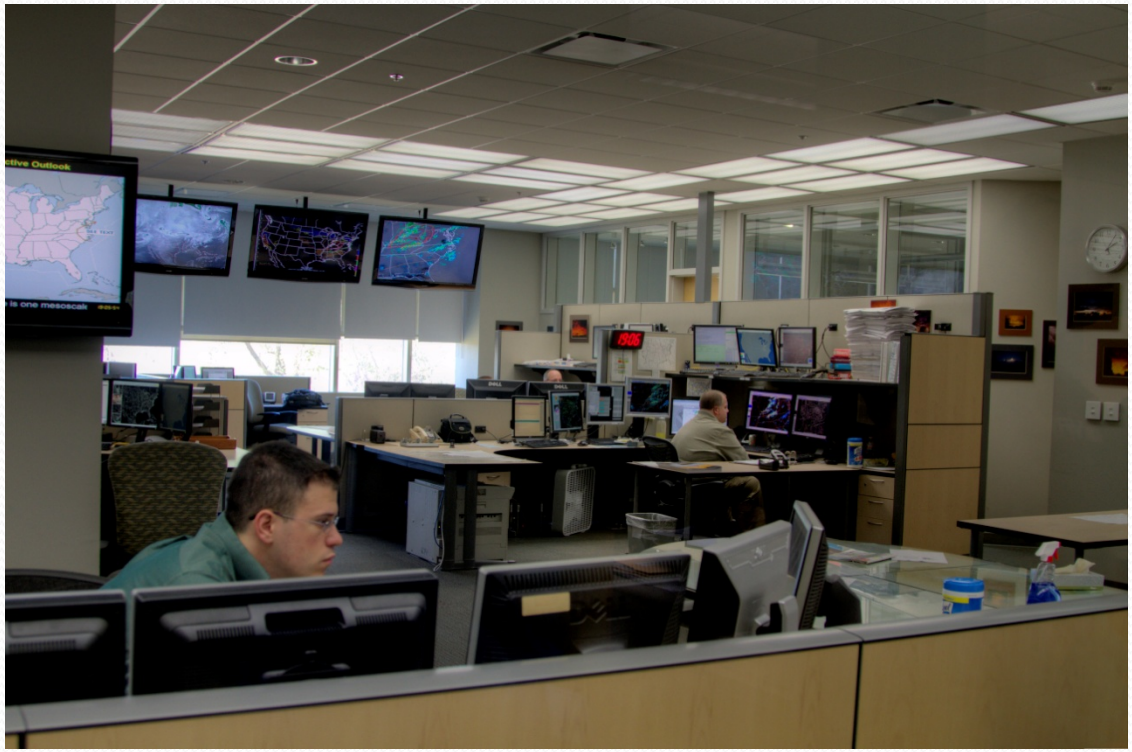
US Storm Prediction Center

- 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

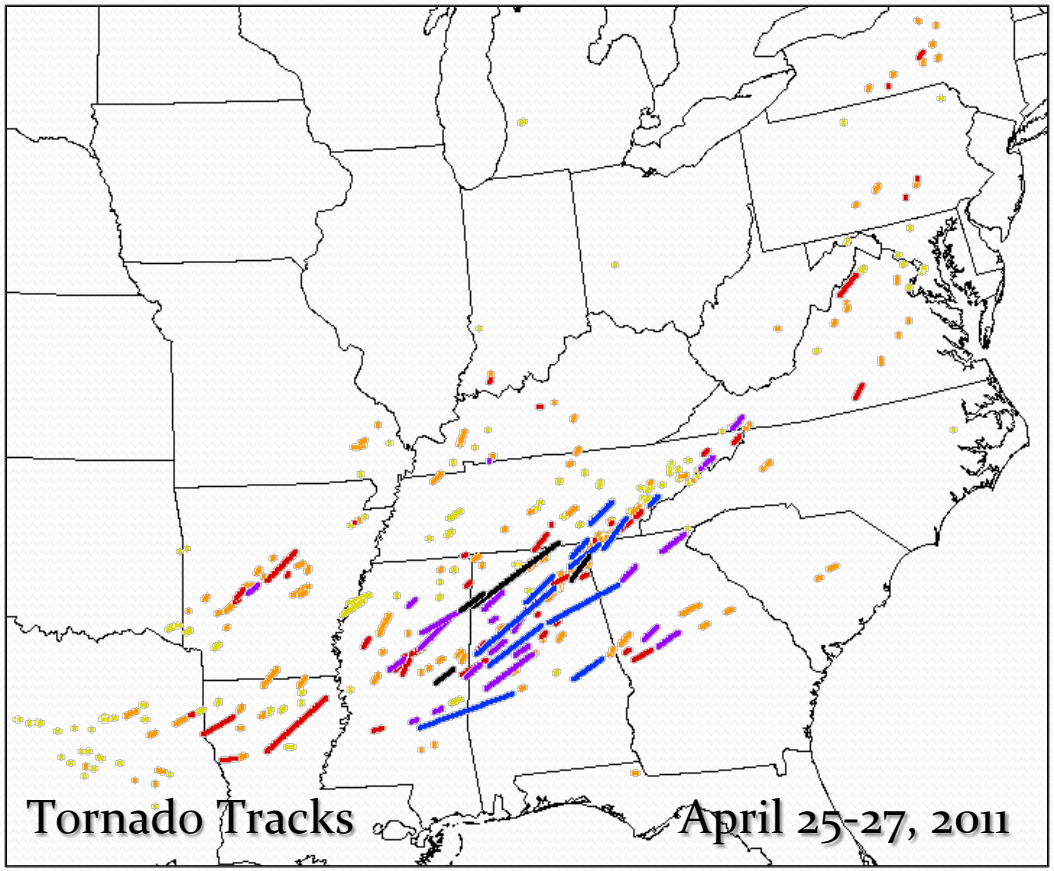
- Career Forecaster
  - 25 years of operational experience
  - 23 years as forecaster at SPC
  - SPC Lead Forecaster for last 13 years
  - Also involved in software development

SPC forecasters typically have at <u>least 10 years</u> of specialized severe storms forecasting experience

Large and Diverse Forecast Area

SPC Overview:

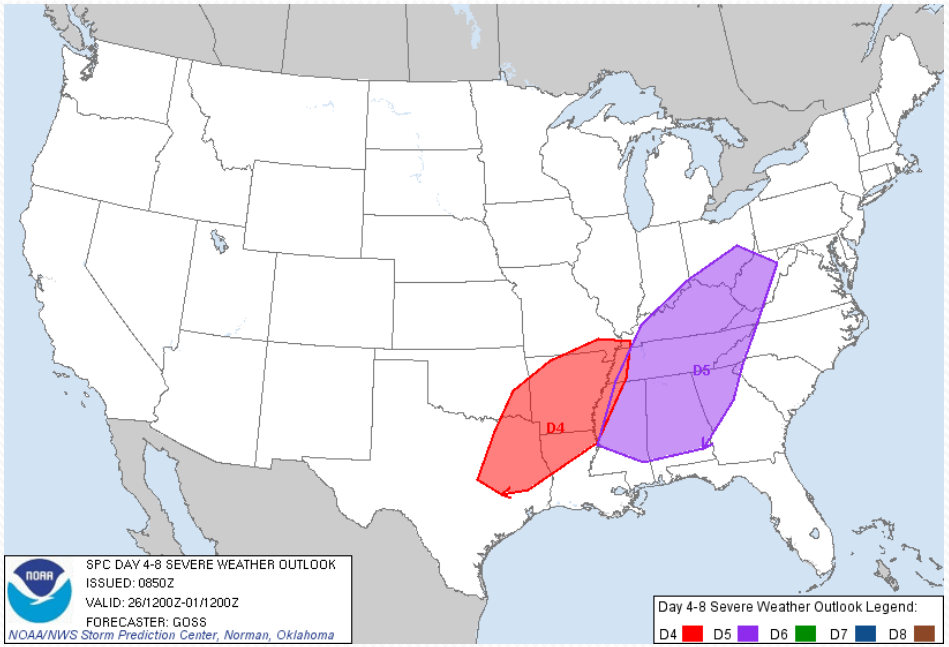
April 27th, 2011 - OUTBREAK



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

SPC Overview:

April 27th, 2011 - OUTBREAK

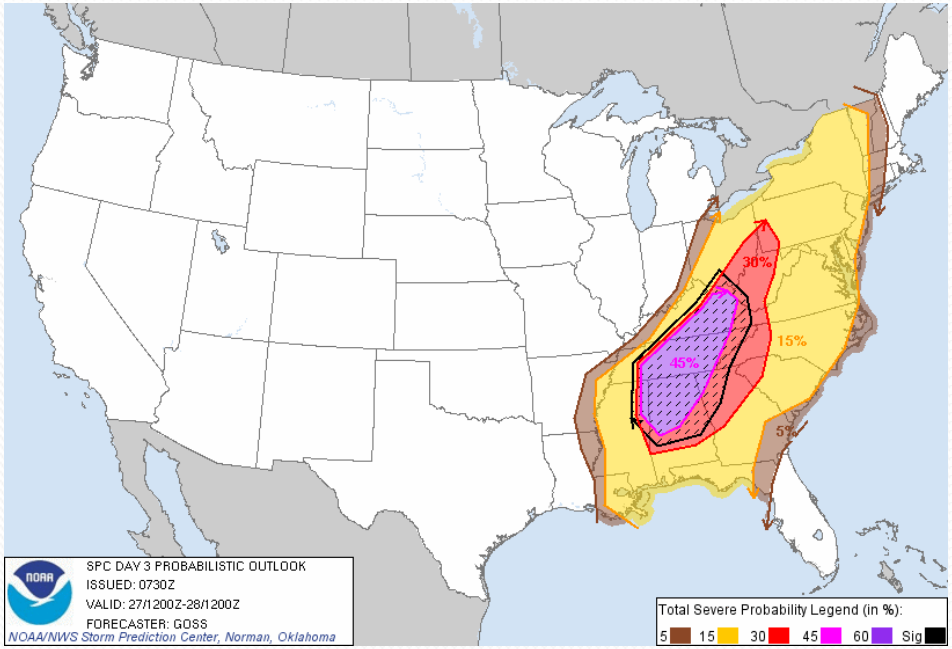


- Began issuing statements on potential 5 days before event.
- Day 5 Outlook:

"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 27th, 2011 - OUTBREAK

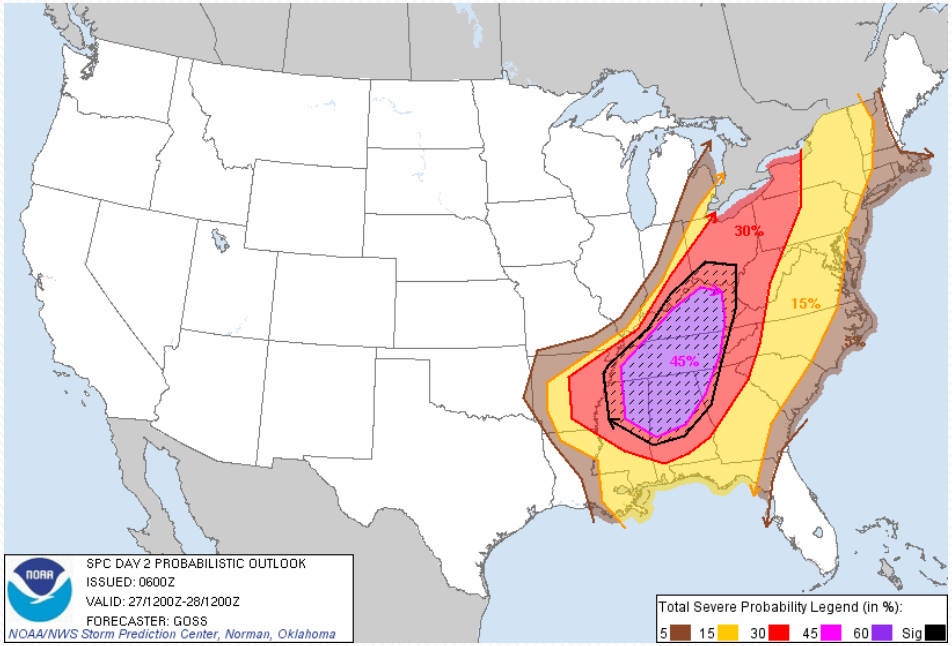


- Day 3 Outlook:
- MODERATE RISK

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

SPC Overview:

April 27th, 2011 - OUTBREAK

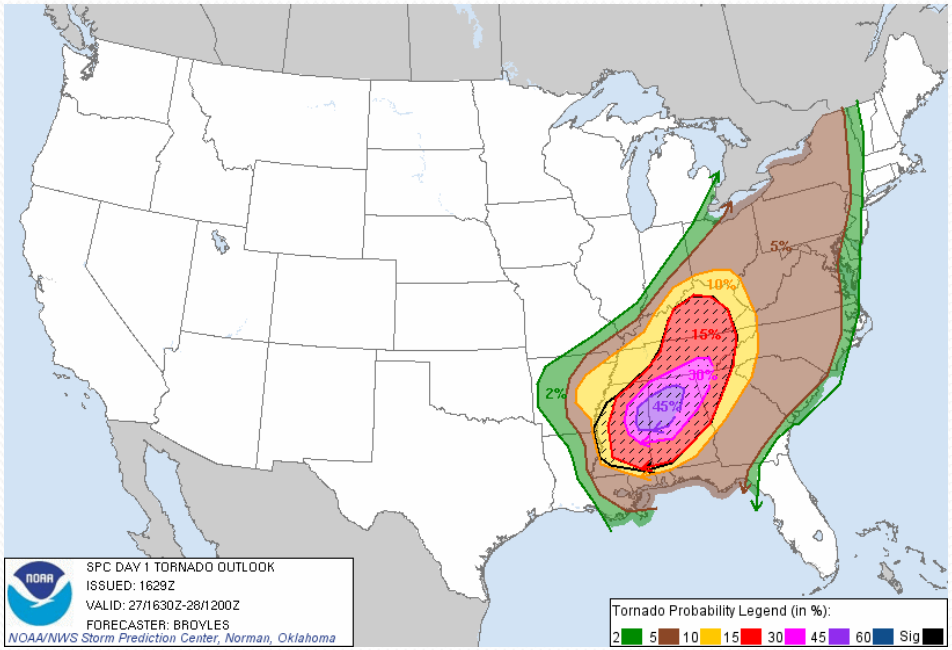


- Day 2 Outlook:
- MODERATE RISK

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

SPC Overview:

April 27th, 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.

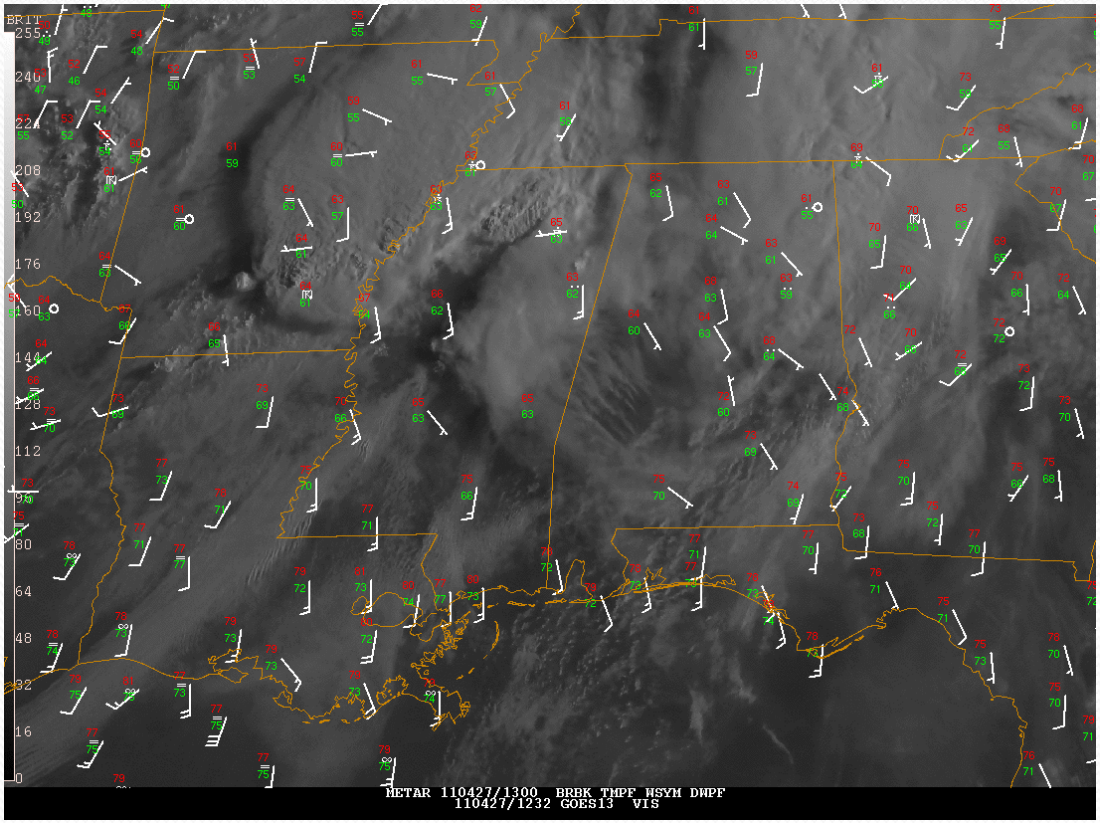
VISIBLE SATELLITE/SURFACE OBSERVATIONAL TRENDS IMPLY RELATIVELY QUICK AIRMASS RECOVERY/ DESTABILIZATION IS OCCURRING FROM LA INTO MS/AL THROUGH MID/LATE MORNING. THIS IS THE CASE NOT ONLY FOR IN THE VICINITY OF EARLY MORNING WEST-EAST OUTFLOW ACROSS MS/AL...WHERE SURFACE TEMPERATURES/DEWPOINTS HAVE EACH 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:

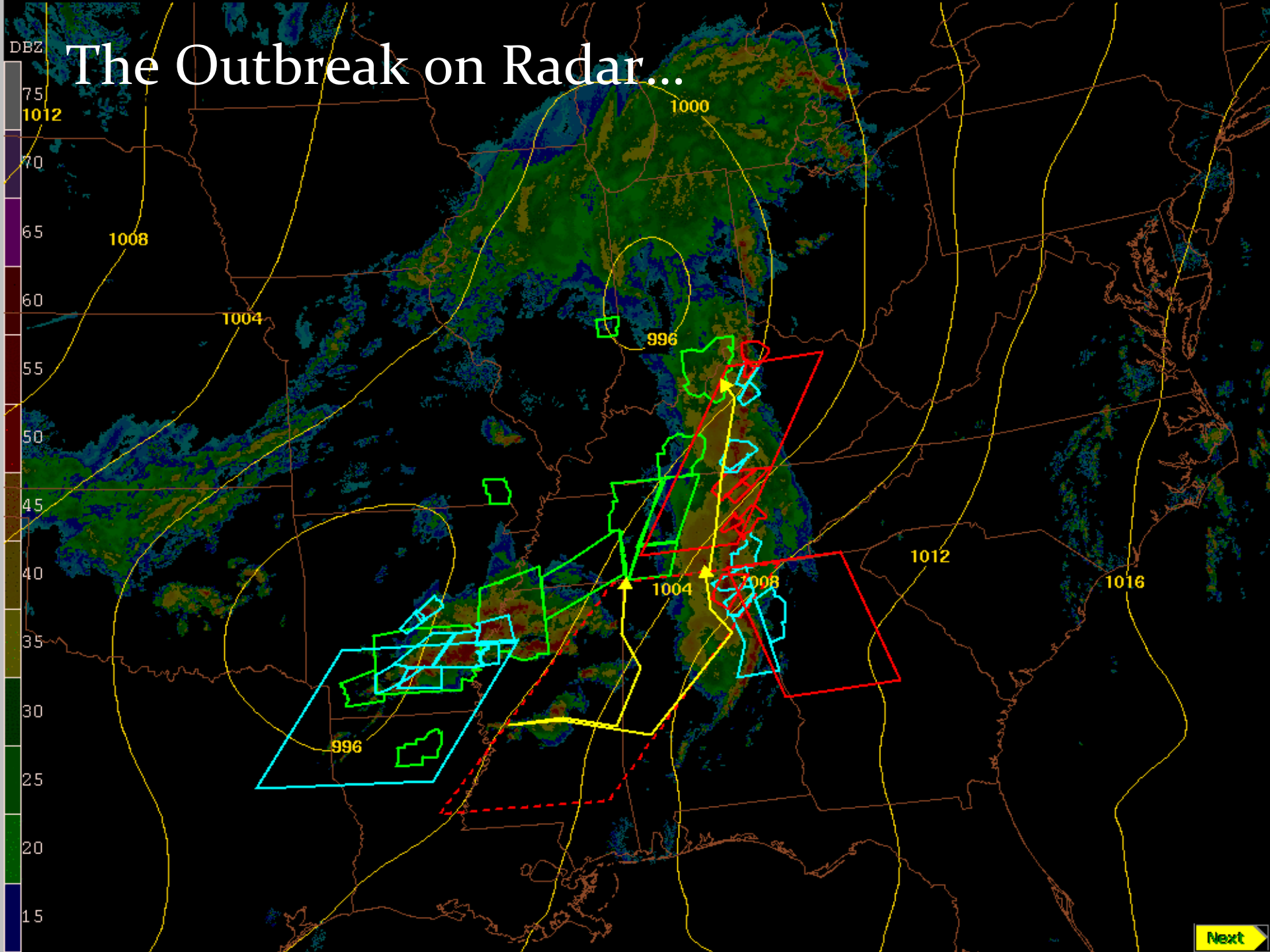
April 27th, 2011 - OUTBREAK



* Mesoscale discussion issued at 1545 UTC.

* Tornado watch issued at 1645 UTC.

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

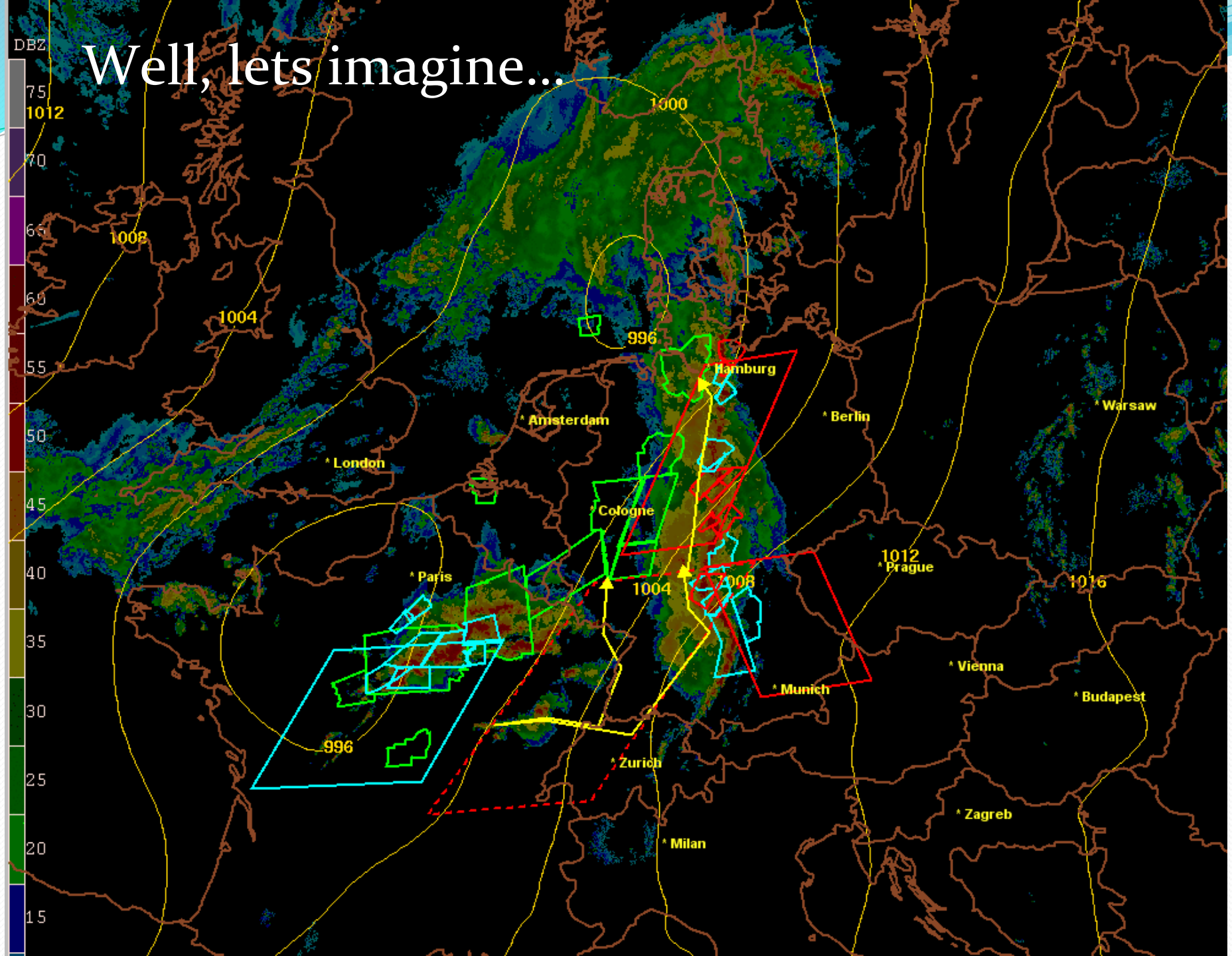

The Outbreak on Radar...
DBZ
75
70
65
60
55
50
45
40
35
30
25
20
15
1012
1000
1008
1004
996
1012
1004
1008
1016
996
Next

SPC Overview:

April 27th, 2011 - OUTBREAK

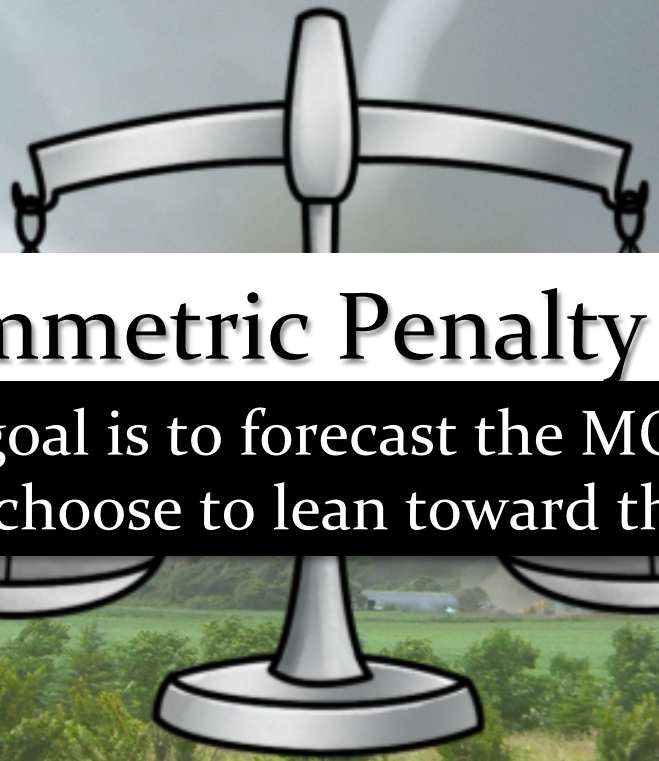
What if…
An event of this extent/magnitude occurred in ***Europe***?

Well, lets imagine...



SPC Overview:

Rare Event Forecasting



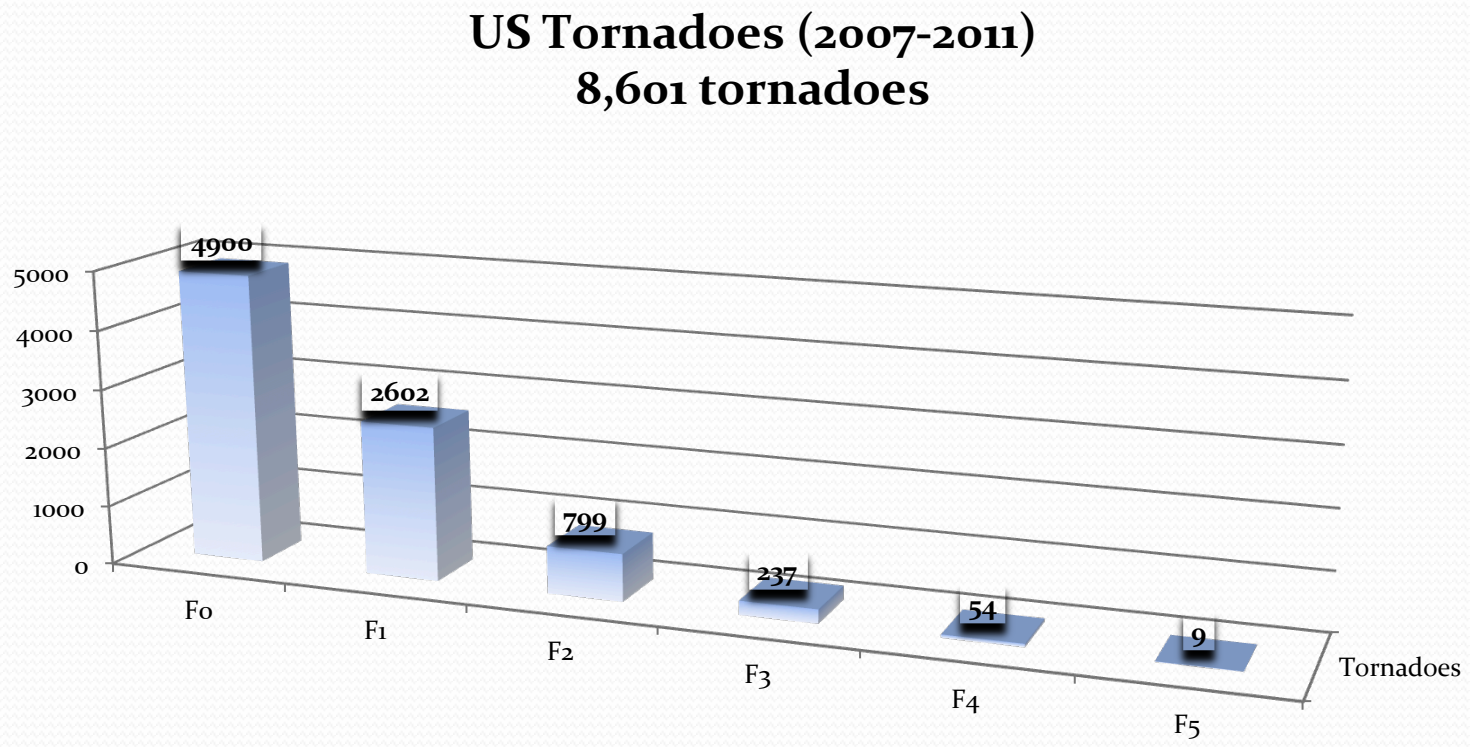
Asymmetric Penalty Function!!!

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

Image source: Steve M., Minnesota Climatology Working Group

SPC Overview:

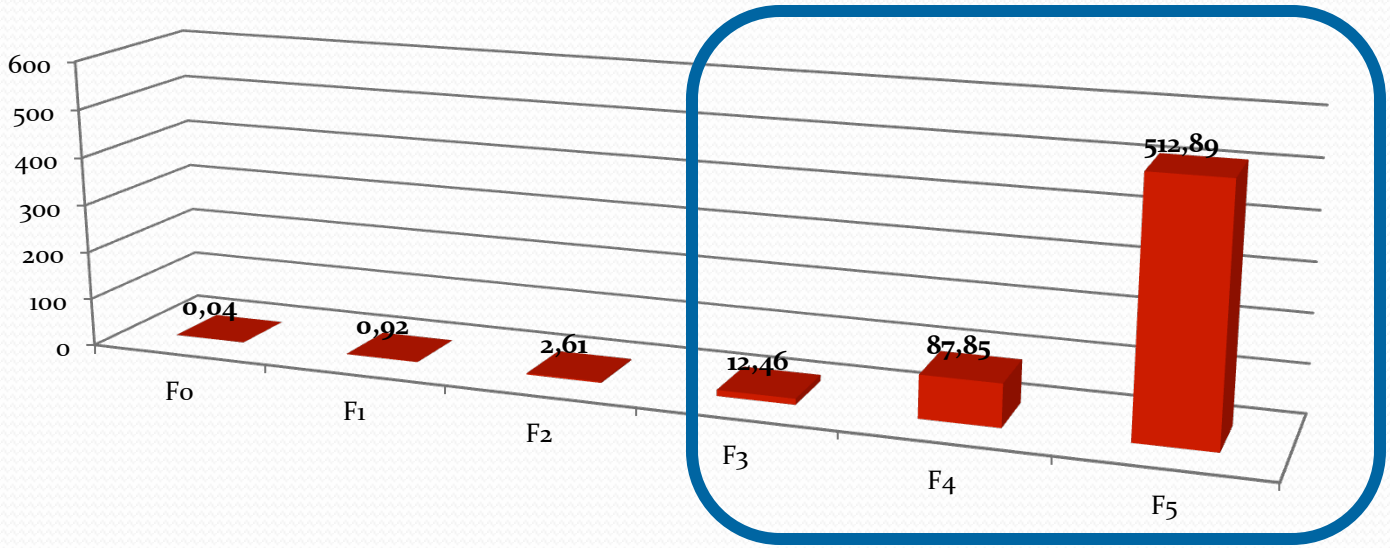
Rare Event Forecasting



SPC Overview:

Rare Event Forecasting

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



3% of tornadoes result in 99% of damage!

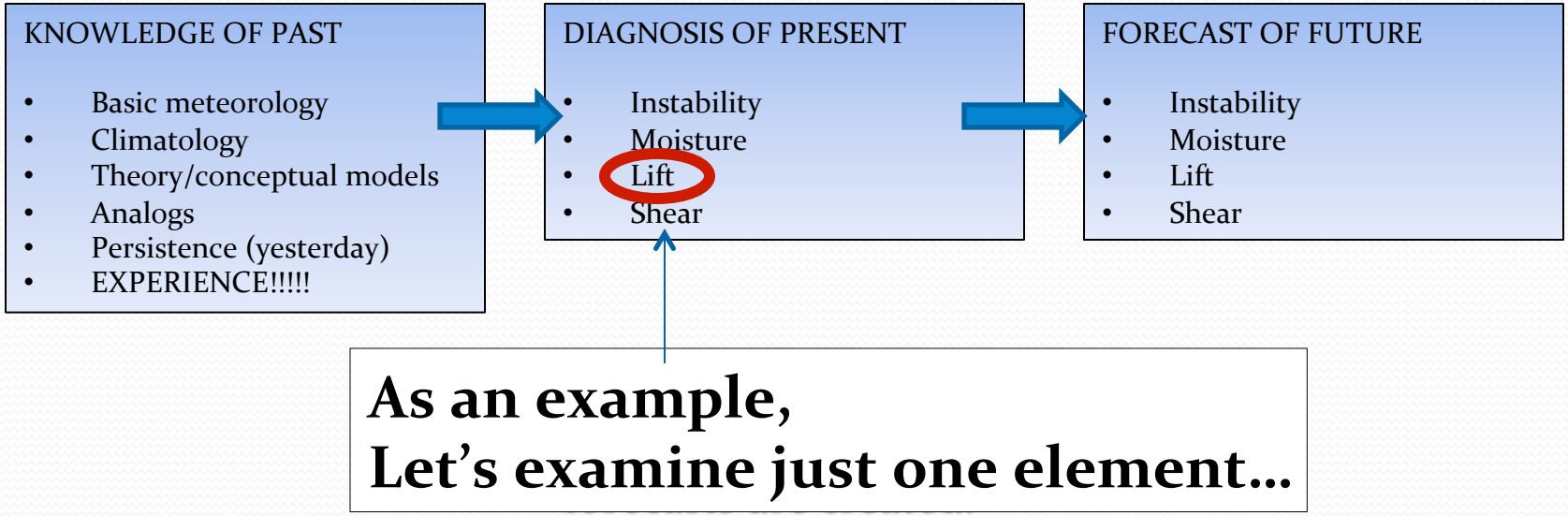
SPC Overview:

Severe Thunderstorm Forecasting

KNOWLEDGE OF PAST	DIAGNOSIS OF PRESENT	FORECAST OF FUTURE
• Basic meteorology • Climatology • Theory/conceptual models • Analogs • Persistence (yesterday) • EXPERIENCE!!!!!	• Instability • Moisture • Lift • Shear	• Instability • Moisture • Lift • Shear
Learned in school, from the literature, and from training.	Requires an investment of time before any forecasts are created.	Only possible after the first two items are satisfied.
Always extremely important.	Most important for short-range forecasts. Less useful for longer-range forecasts.	Rarely if ever get it ALL right.

SPC Overview:

Severe Thunderstorm Forecasting



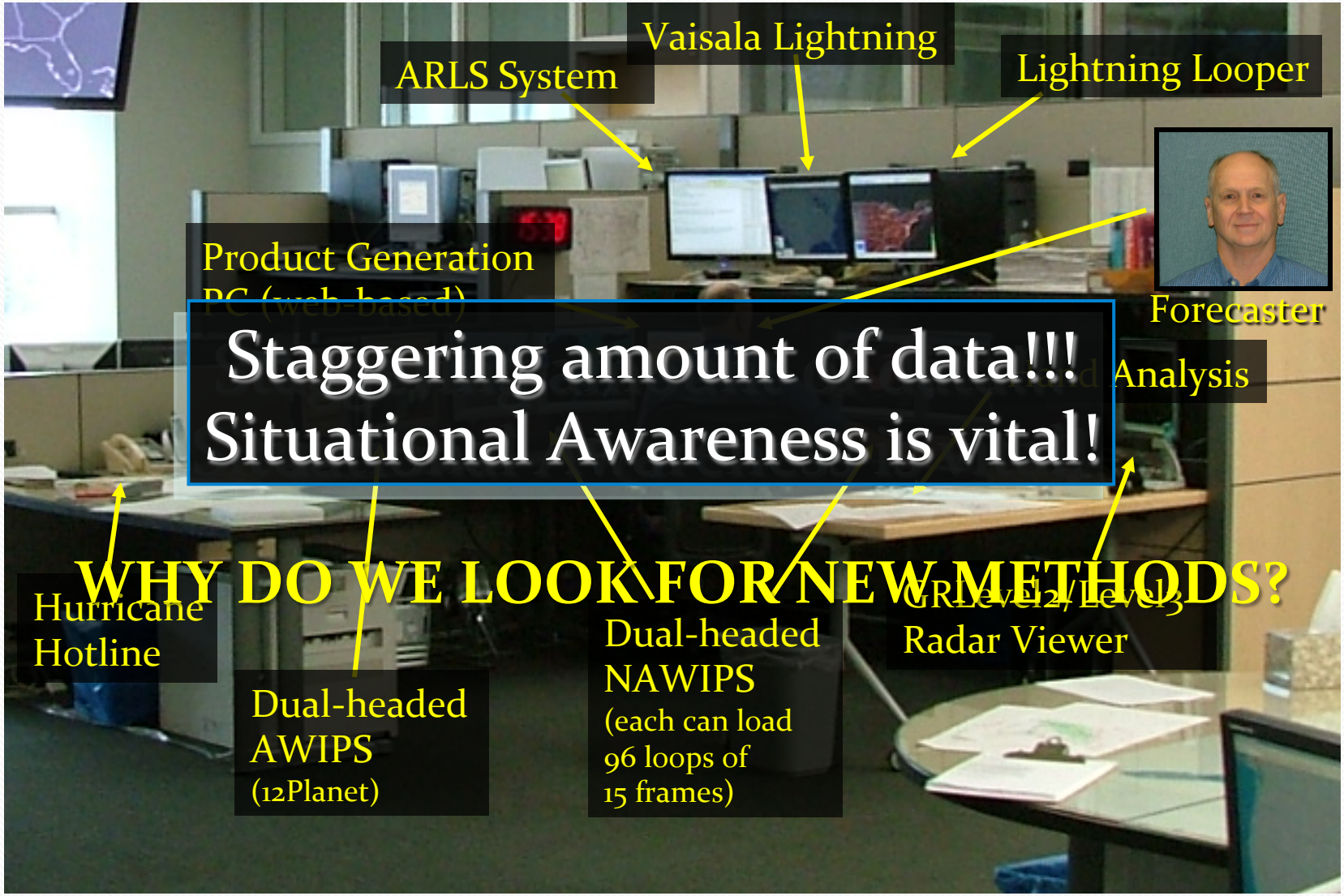
SPC Overview:

Severe Thunderstorm Forecasting

Diagnosing Lift:

Satellite i
- Boundar
- Cumulus
- Gravity v
- Shortwa
- Moisteni
- Cooling
- Deepeni
- 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…


ARLS System
Vaisala Lightning
Lightning Looper
Product Generation
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)
GRLevel2/Level3
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 <u>ESSENTIAL</u> to severe weather forecasting.

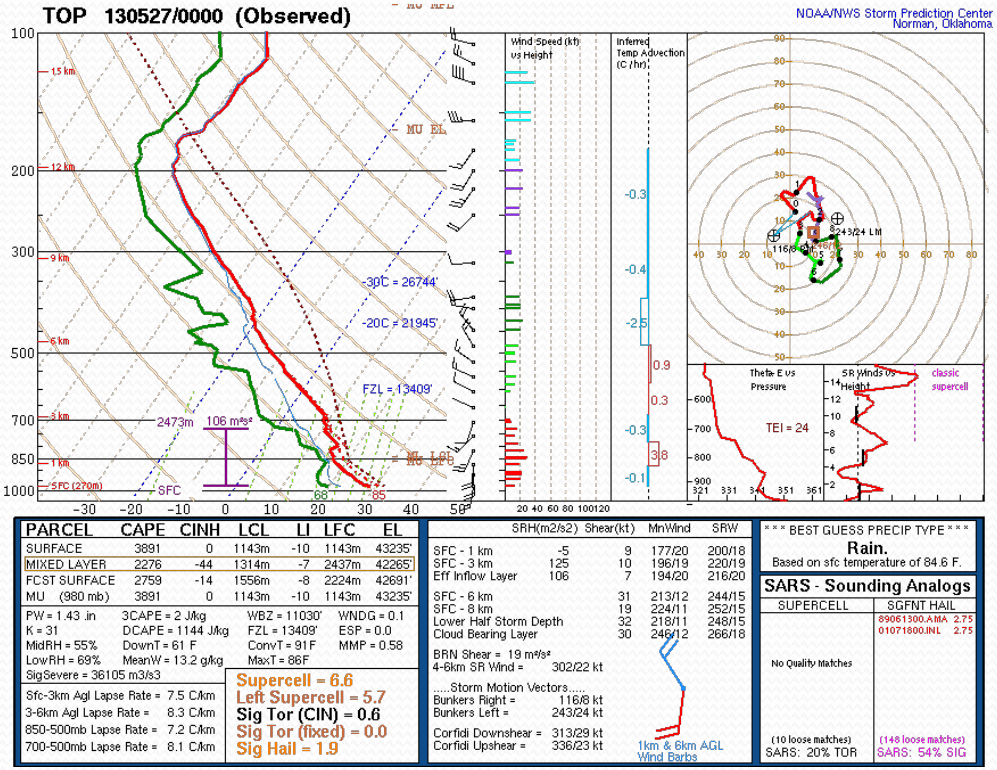
New Methods…

*** 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.

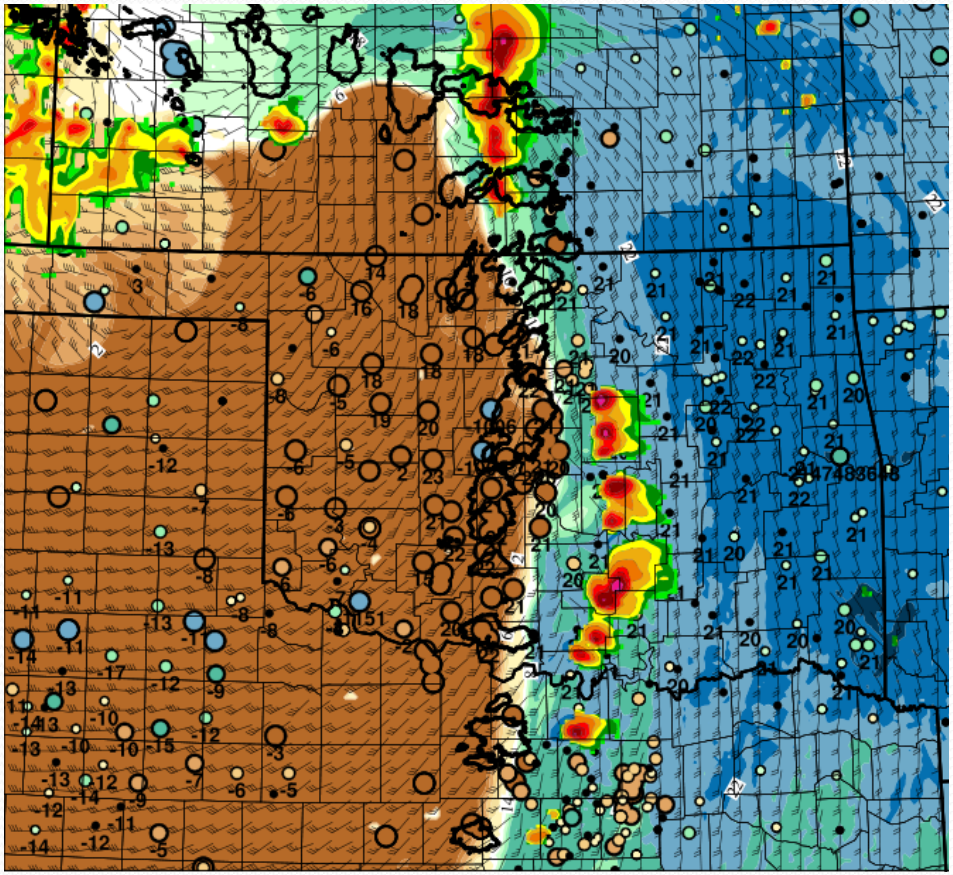
THIS IS A PARTICULARLY DANGEROUS SITUATION.

HAZARD...DAMAGING TORNADO.

SOURCE...EMERGENCY MANAGEMENT CONFIRMED TORNADO.

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 m^2/s^2
  - Updraft Speed > 10 m/s
  - 10m Wind Speed > 30 knots
  - Reflectivity > 40 dBZ



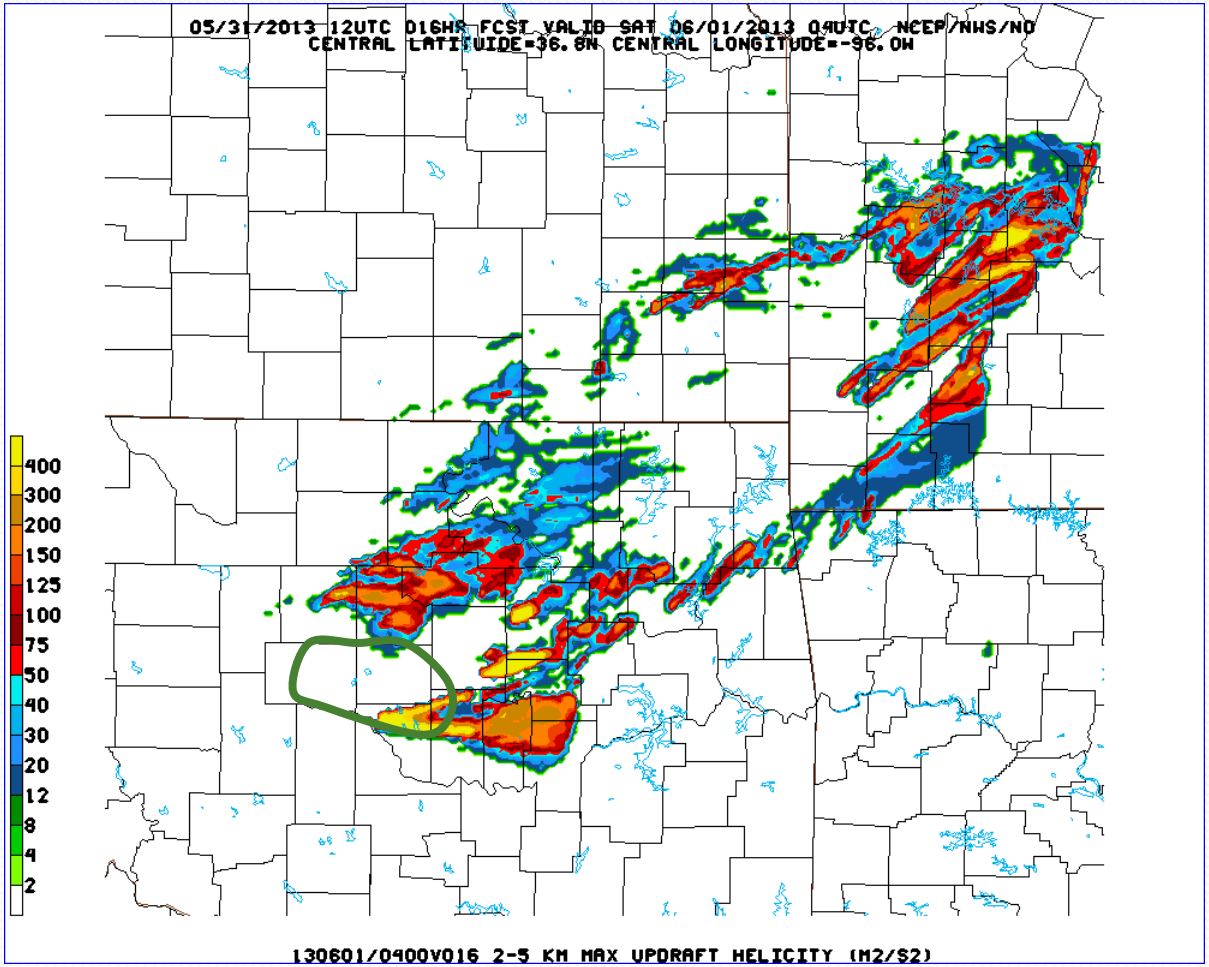
Storm-Resolving models

- High detail can easily be taken literally (mistake)

Wasn't that wonderful!

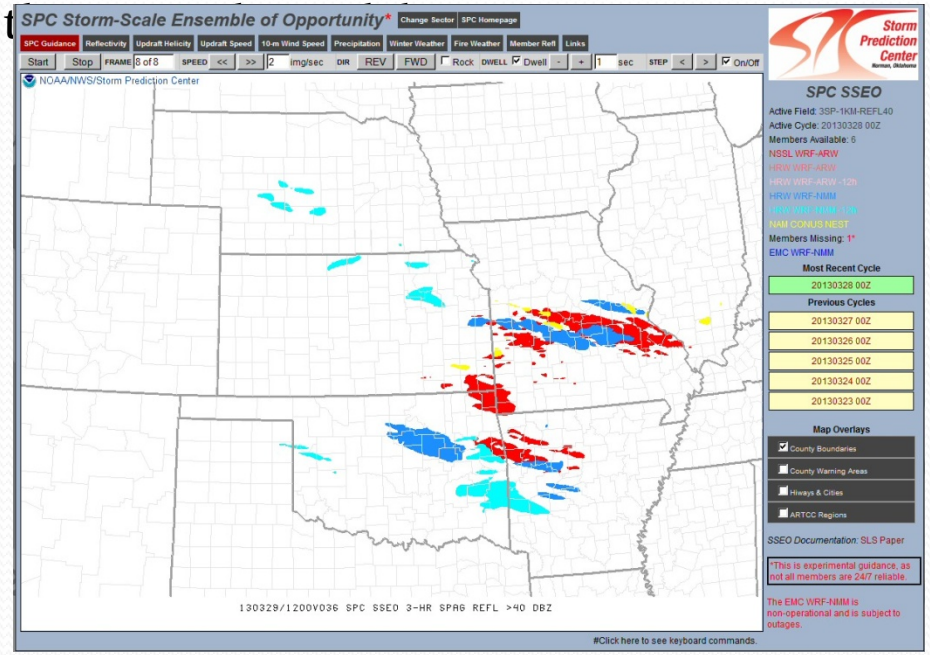
I wish it did that everyday But…it does not.

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



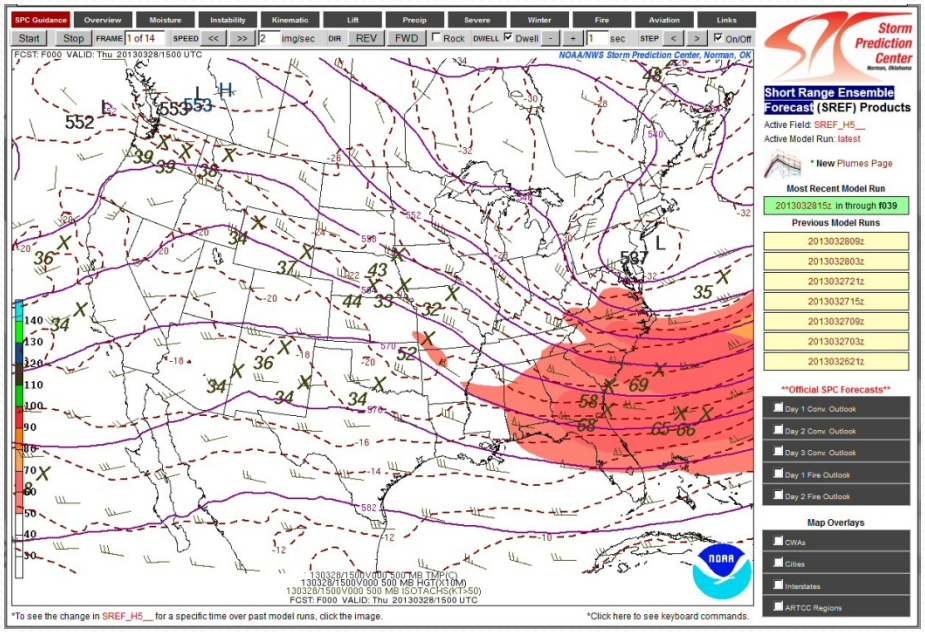
SSEO (Storm-Scale Ensemble of Opportunity)
http://www. spc.noaa.gov/exper/sseo

- 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 t
  - 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

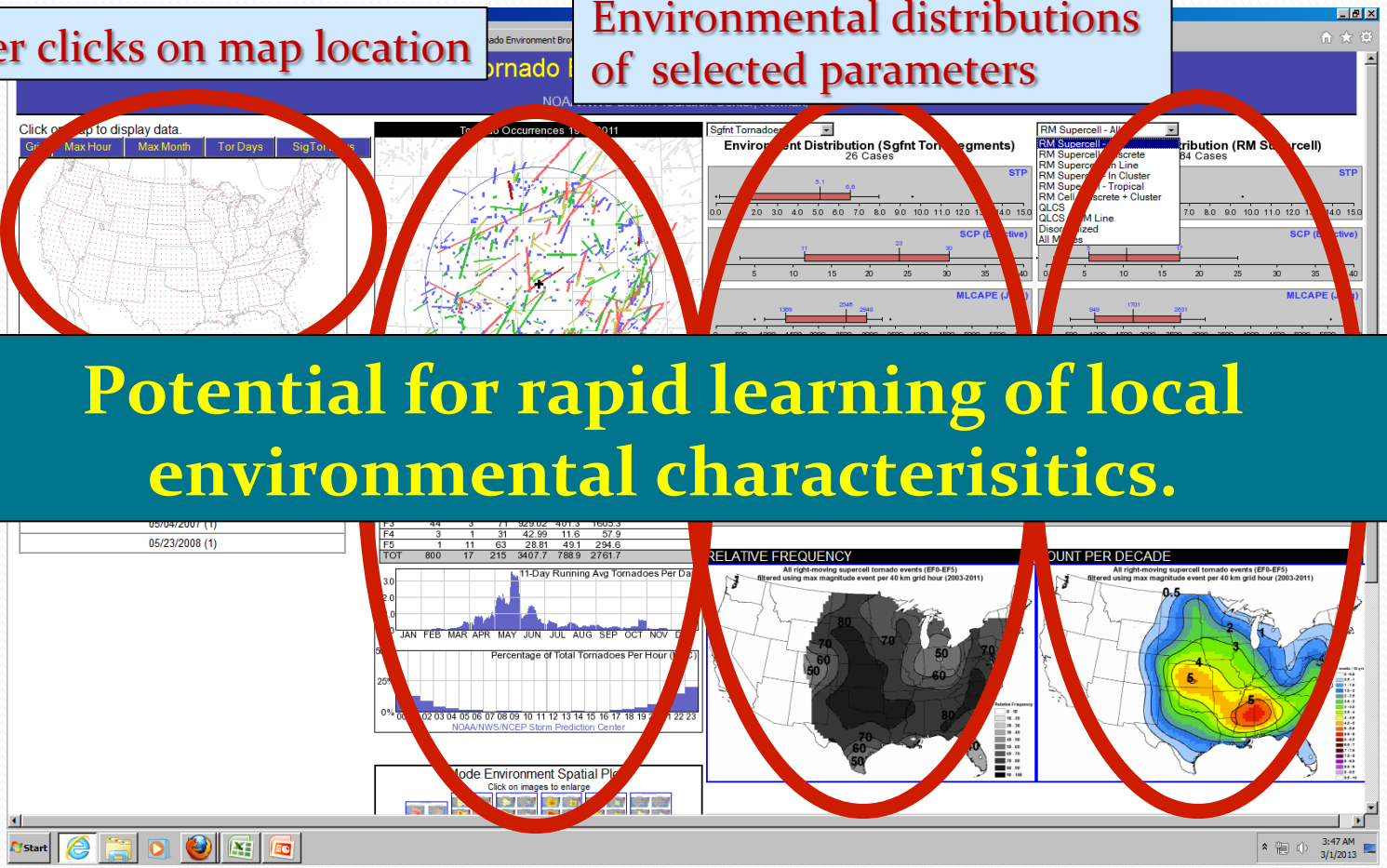
http://ww…ov/exper/envbrowser

50 year tornado climatology

Parameter distributions by convective mode

User clicks on map location

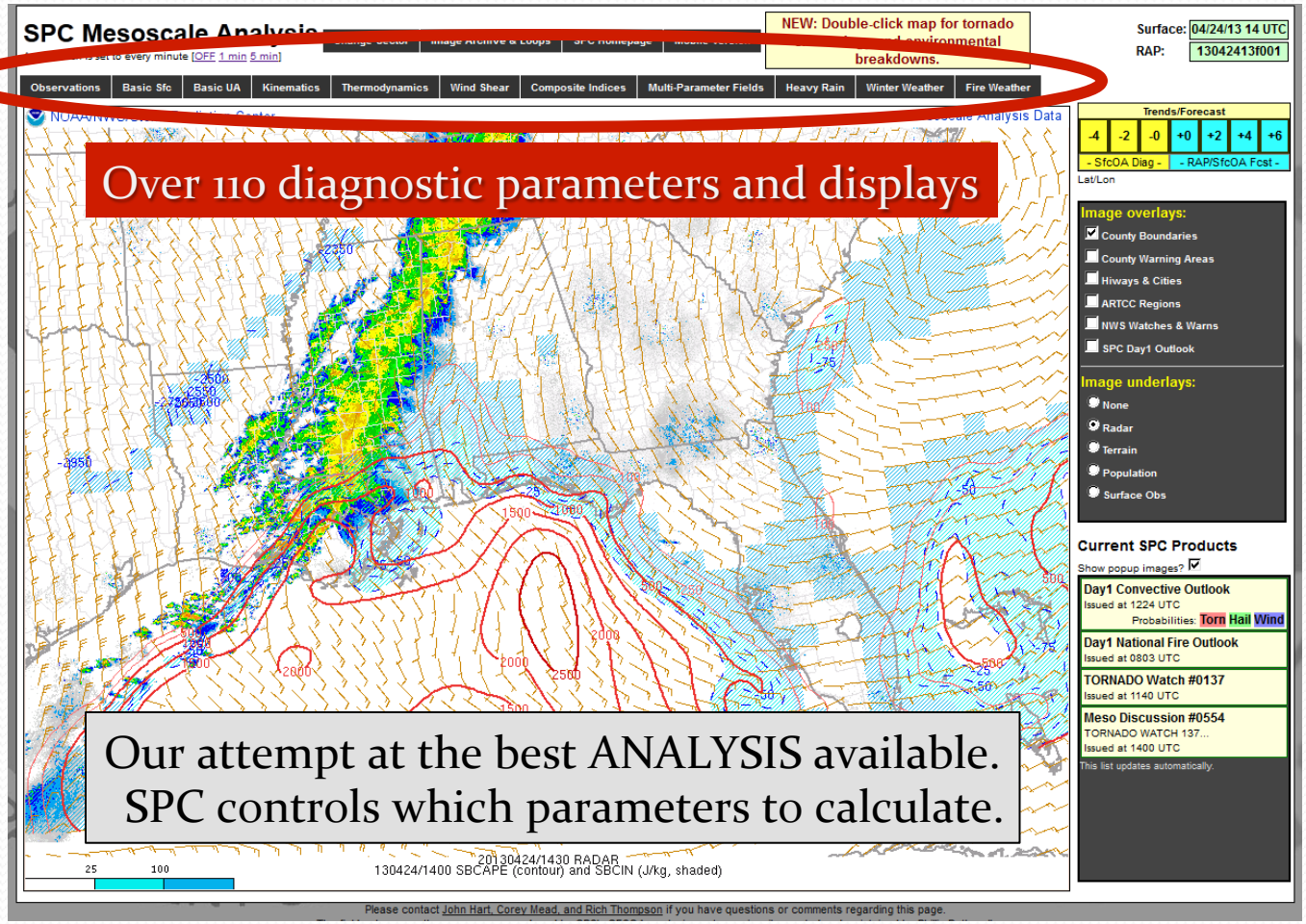
Environmental distributions of selected parameters



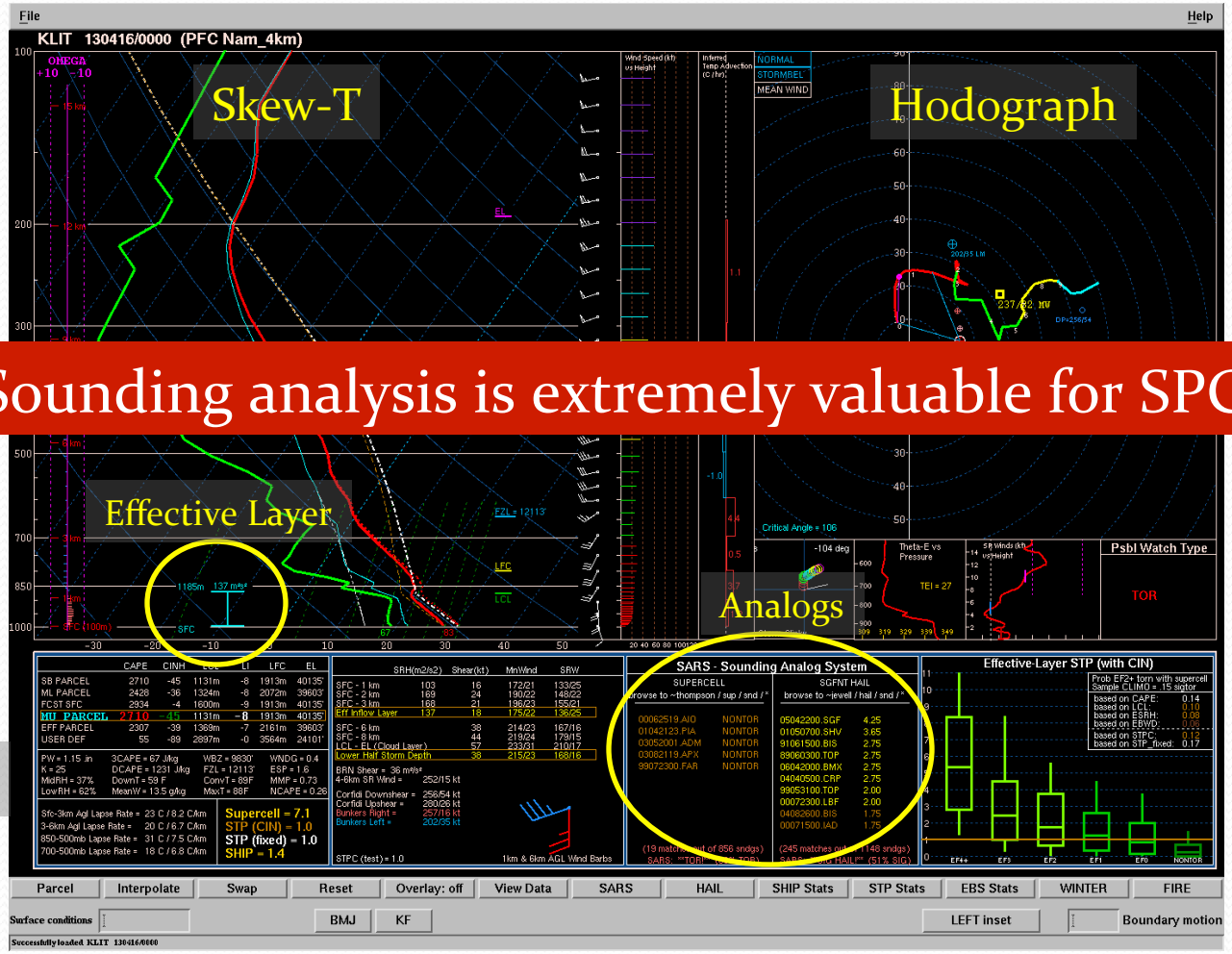
Potential for rapid learning of local environmental characterisitics.

Mesoanalysis Diagnostic Data

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



Observed and Forecast Soundings



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)

Photo by John Kerstholt

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…**

Photo by John Kerstholt

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)

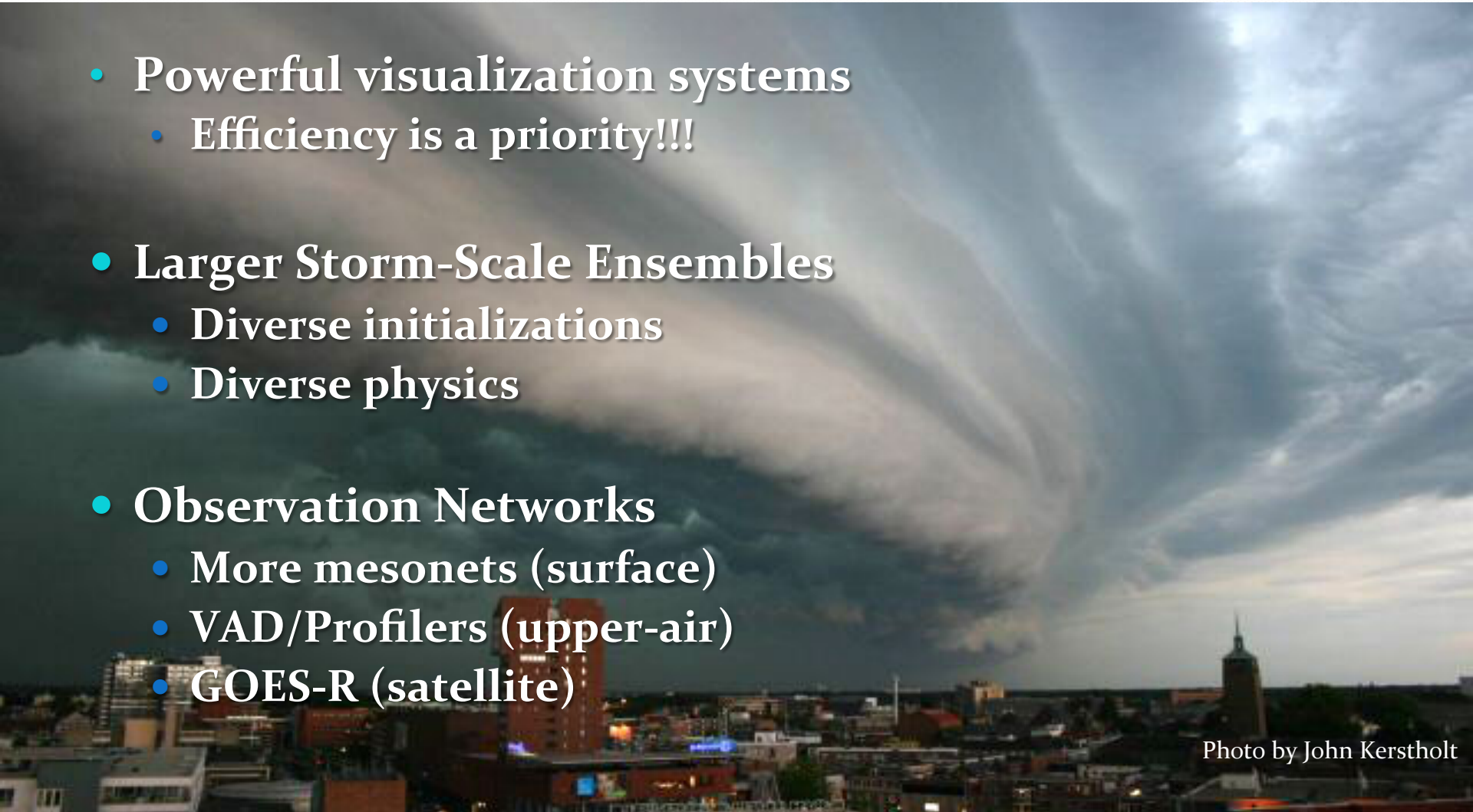


Photo by John Kerstholt

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