An Update on Verification of NHC Forecasts of Extratropical Transition

Jack Beven and Colleagues (with an assist from Jay Hobgood and Nick D'Allura)

NATIONAL HURRICANE CENTER

WHERE AMERICA'S CLIMATE AND WEATHER SERVICES BEGIN

ma AVHRR NCOL - 2011-08-28 15:09UTC

Outline

- Background
- Verification Methodology
- Results
- A Couple of Interesting Cases

Hurricane Lili (1996)

"Obviously we have little skill with Lili in forecasting extratropical transition" – Lixion Avila

Fcst Time	Mean Error (hr)
12 hr	39.43
24 hr	99.00
36 hr	27.00
48 hr	42.00
72 hr	24.00

In terms of timing, this is still the worst forecast ET event in the forecast verification data set.

ET Verification Principles

- Potential ET cases includes all cyclones where ET either occurred or was forecast
- All cases includes all cyclones whether ET was forecast/occurred or not
- Forecast ET was based on designation of “extratropical” in the forecast package.
- Actual ET was based on designation of “extratropical” in the best track.
- A tropical cyclone absorbed by a front without any subsequent ET positions was treated as dissipation, not transition.
- ET forecast later than actually occurred was assigned a negative timing error. ET forecast earlier than actually occurred was assigned a positive timing error.

ET Verification Metrics (I)

- Based on the 2x2 contingency table used by the NWS for severe local storms verification - was ET forecast (yes or no) and did it occur (yes or no)?
- www.sec.noaa.gov/forecast_verification/Glossary.html
- Probability of Detection (POD) – Percentage of the occurring ET events that were forecast - from 0 (totally wrong) to 1 (perfect)
- False Alarm Ratio (FAR) – Percentage of the forecast ET events that did not occur – scores range from 0 (no false alarms) to 1 (all false alarms)
- Critical Success Index (CSI) – Ratio of the number of forecast ET events to the total number of ET forecasts + the missed ET occurrences – scores range from 0 (totally wrong) to 1 (perfect)

Verification Table for 2011

		ET Observed	
	417 forecasts	Yes	No
ET Forecast	Yes	106 (successfully forecast ET)	35 (false alarms)
	No	15 (missed transitions)	261 (successfully forecast non-ET)

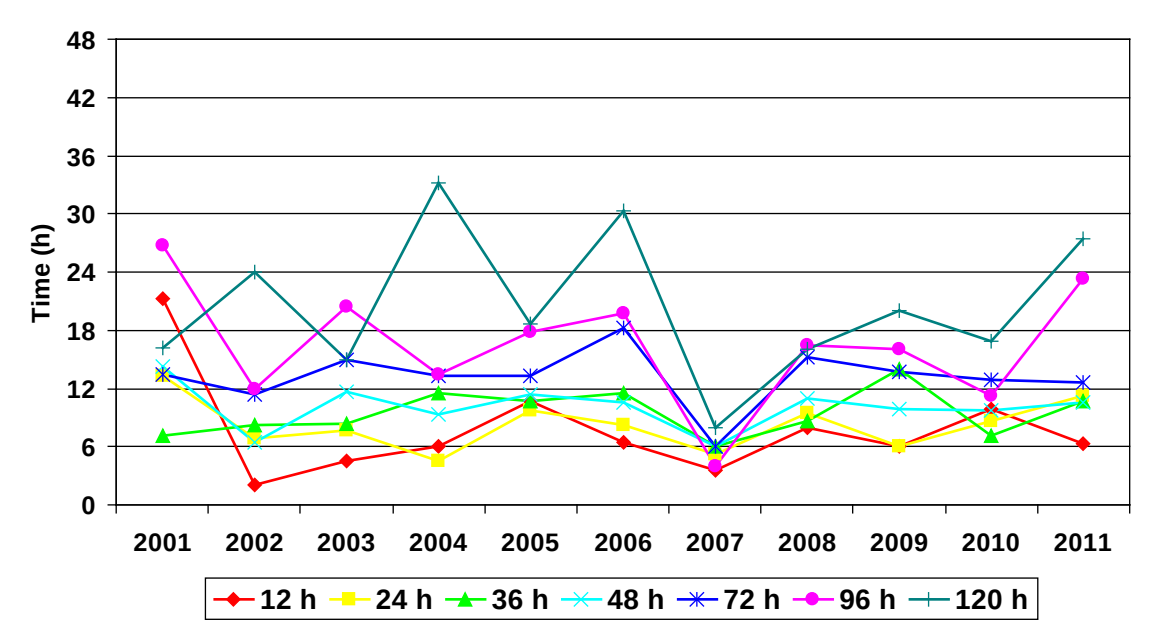
ET Verification Metrics (II)

- Percent Correct – Percentage of forecasts that either correctly forecast ET or lack thereof
- Event Bias – ratio of the number of times ET was forecast to the number of times it was observed
- Gilbert Skill Score – Unbiased version of the CSI accounting for the number of forecasts that were correct by chance – scores range from -0.33 to 1.0 (best) with negative values indicating forecasts worse than chance
- Heidke Skill Score – Skill-corrected verification measure accounting for correct random forecasts – scores range from -1.0 (no correct forecasts) to 1.0 (no incorrect forecasts)
- True Skill Statistic (Peirce Skill Score or Kuipers' Performance Index) – Verification measure accounting for unbiased random forecasts - 1.0 score reflects perfect forecasts, 0.0 score reflects random forecasts, and negative scores for worse than random forecasts

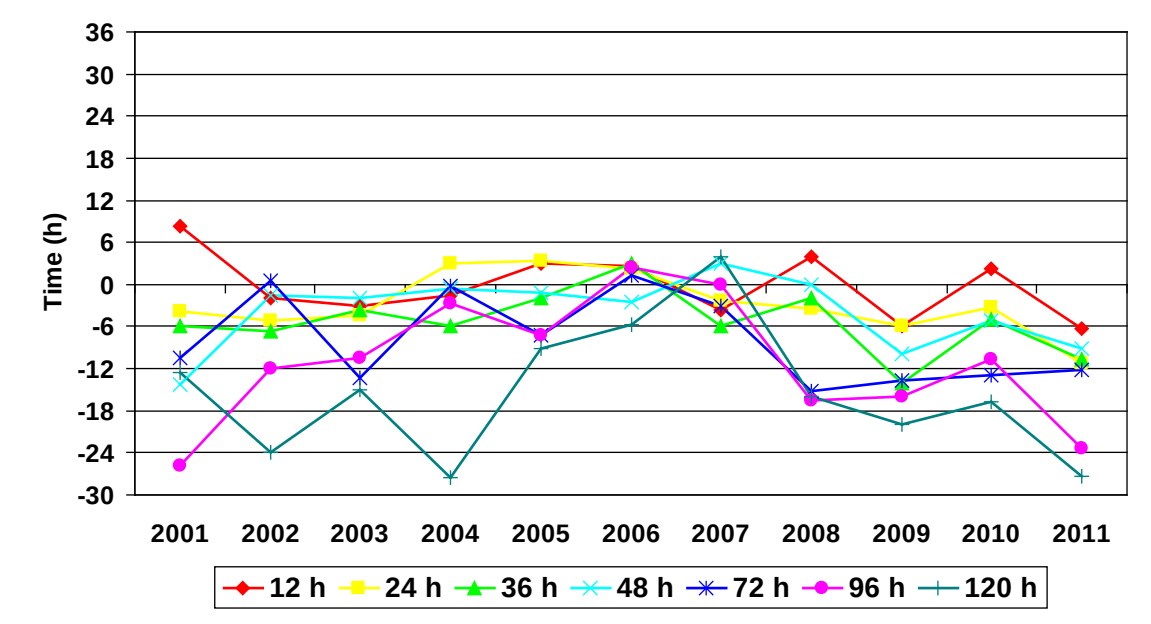
5-Day Potential ET Cases Only

Over the past decade, NHC forecasts of ET have a clear negative bias – ET usually occurs earlier than NHC forecast at all forecast times.

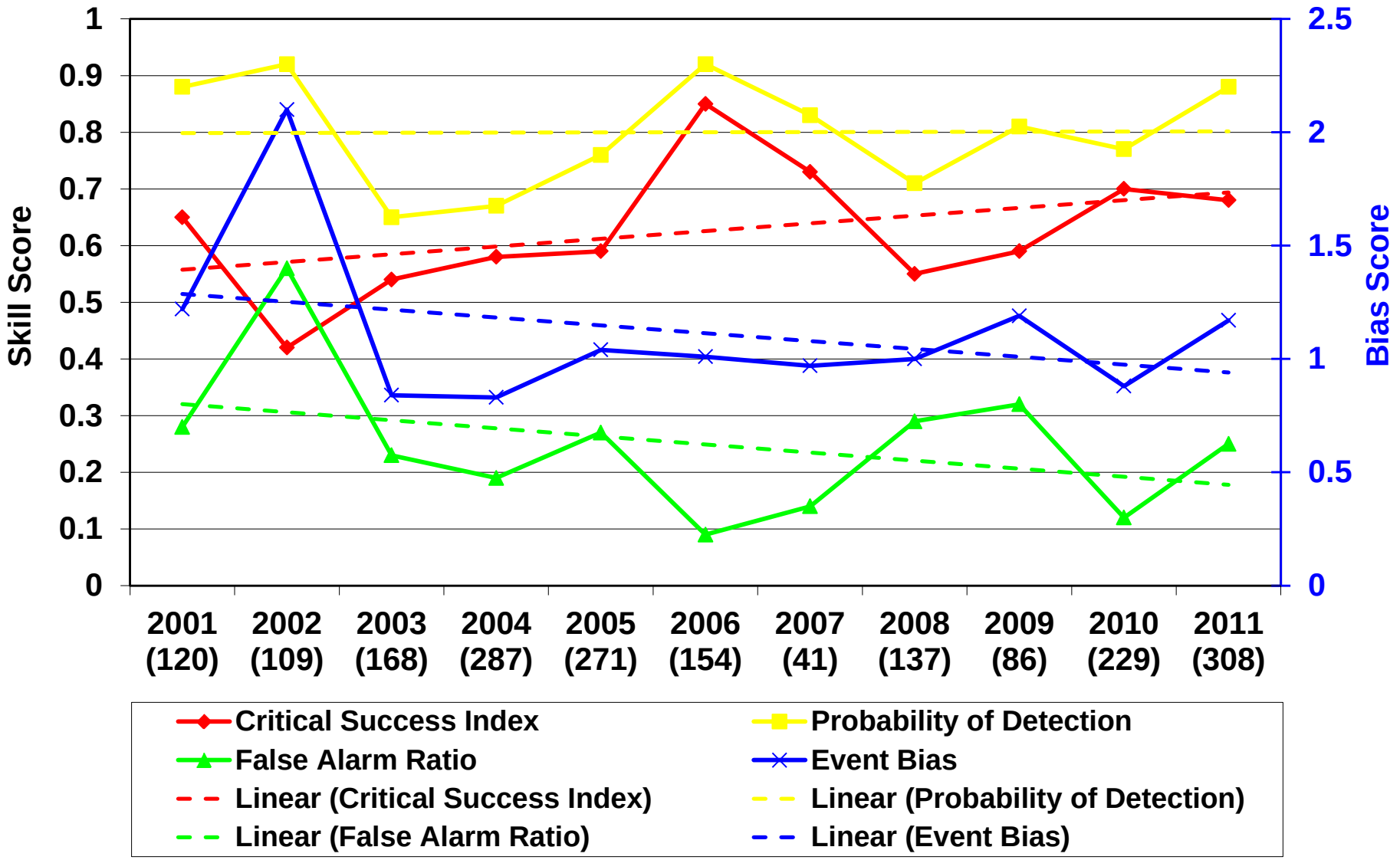
Mean ET Forecast Error (h)



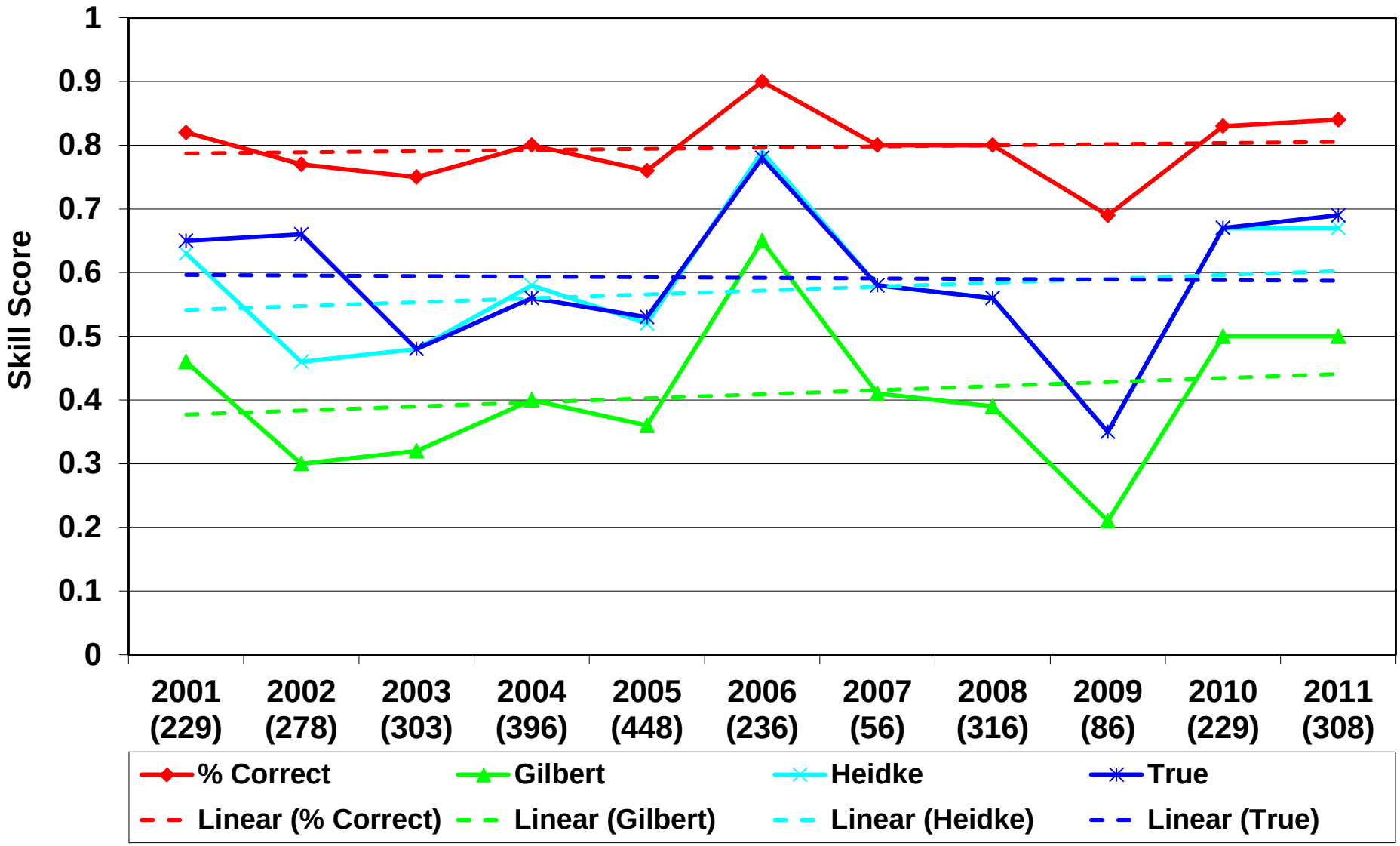
Mean ET Forecast Bias (h)



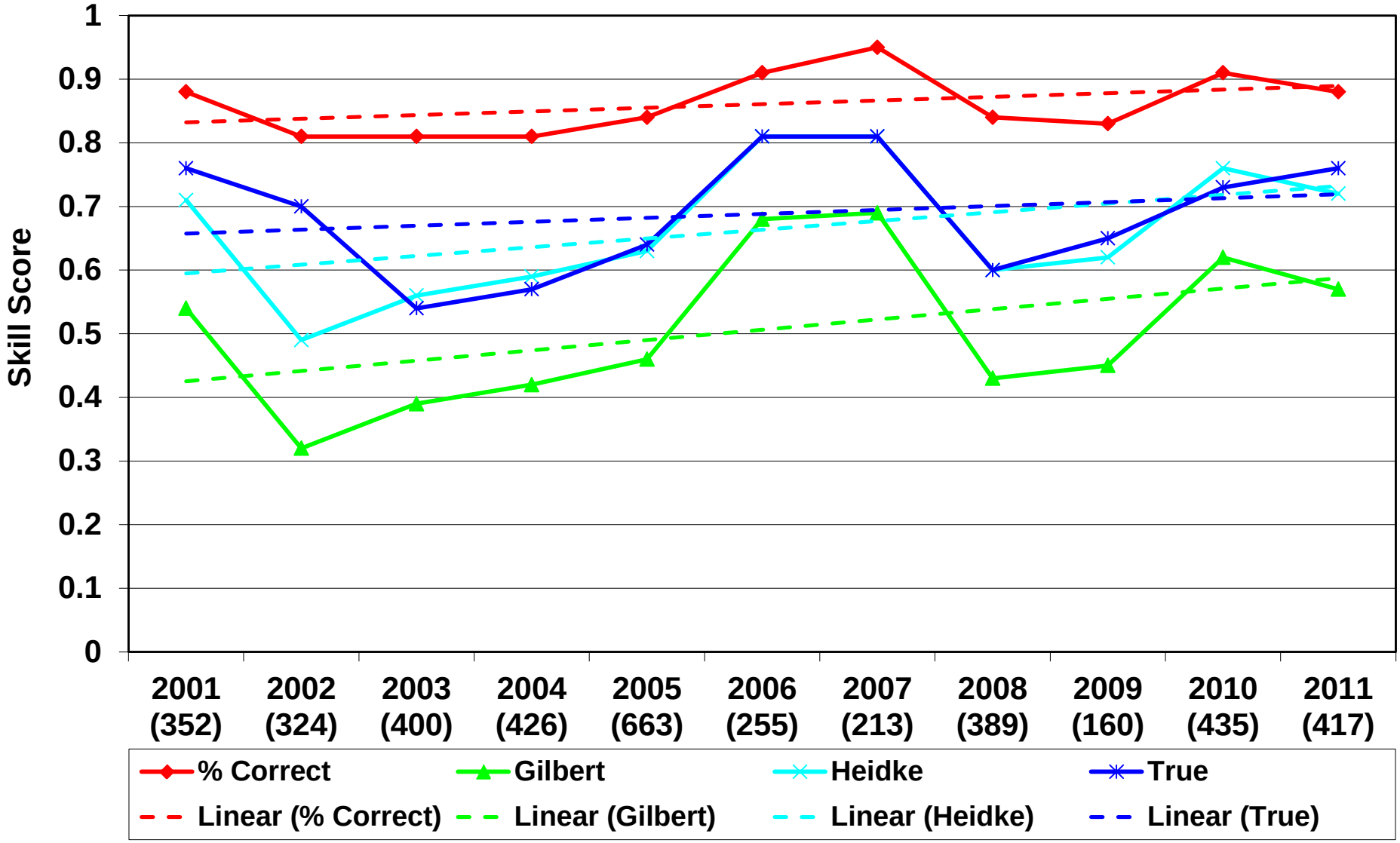
5-Day Potential ET Cases Only



5-Day Potential ET Cases Only



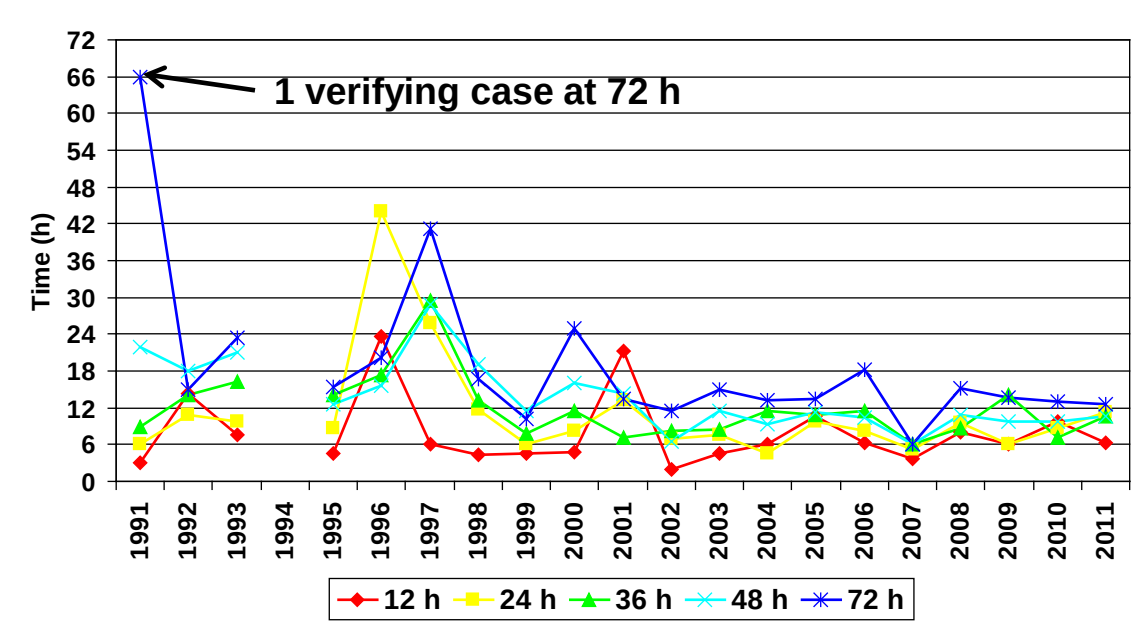
5-Day All Forecast Cases



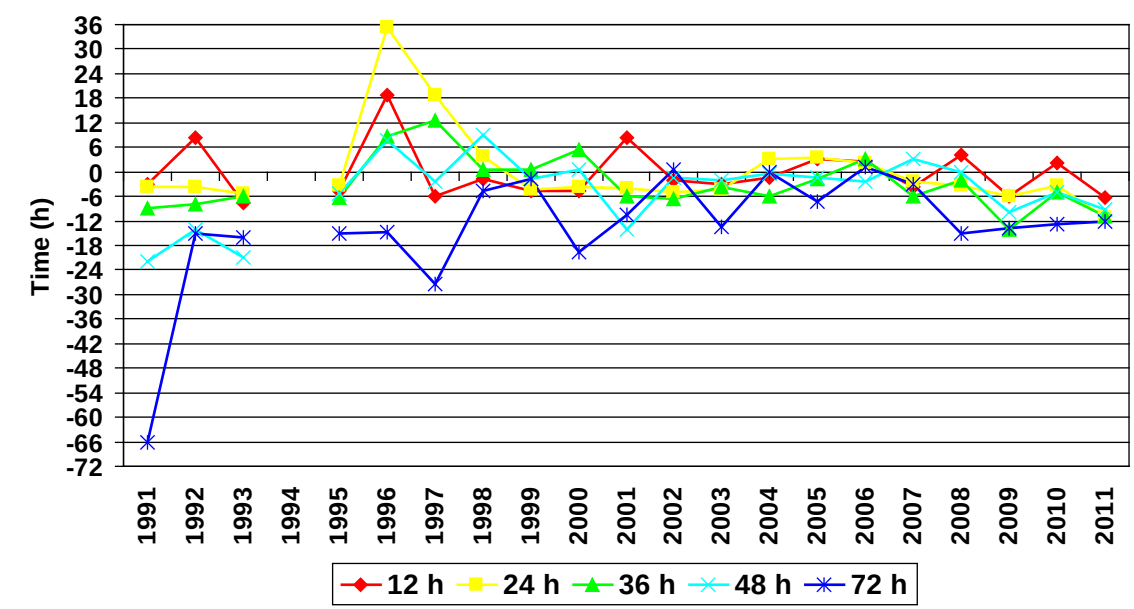
3-Day Potential ET Cases Only

Positive biases (some quite large) existed for much of the 1990's. Since then, the biases have become persistently negative – ET occurs before it is forecast.

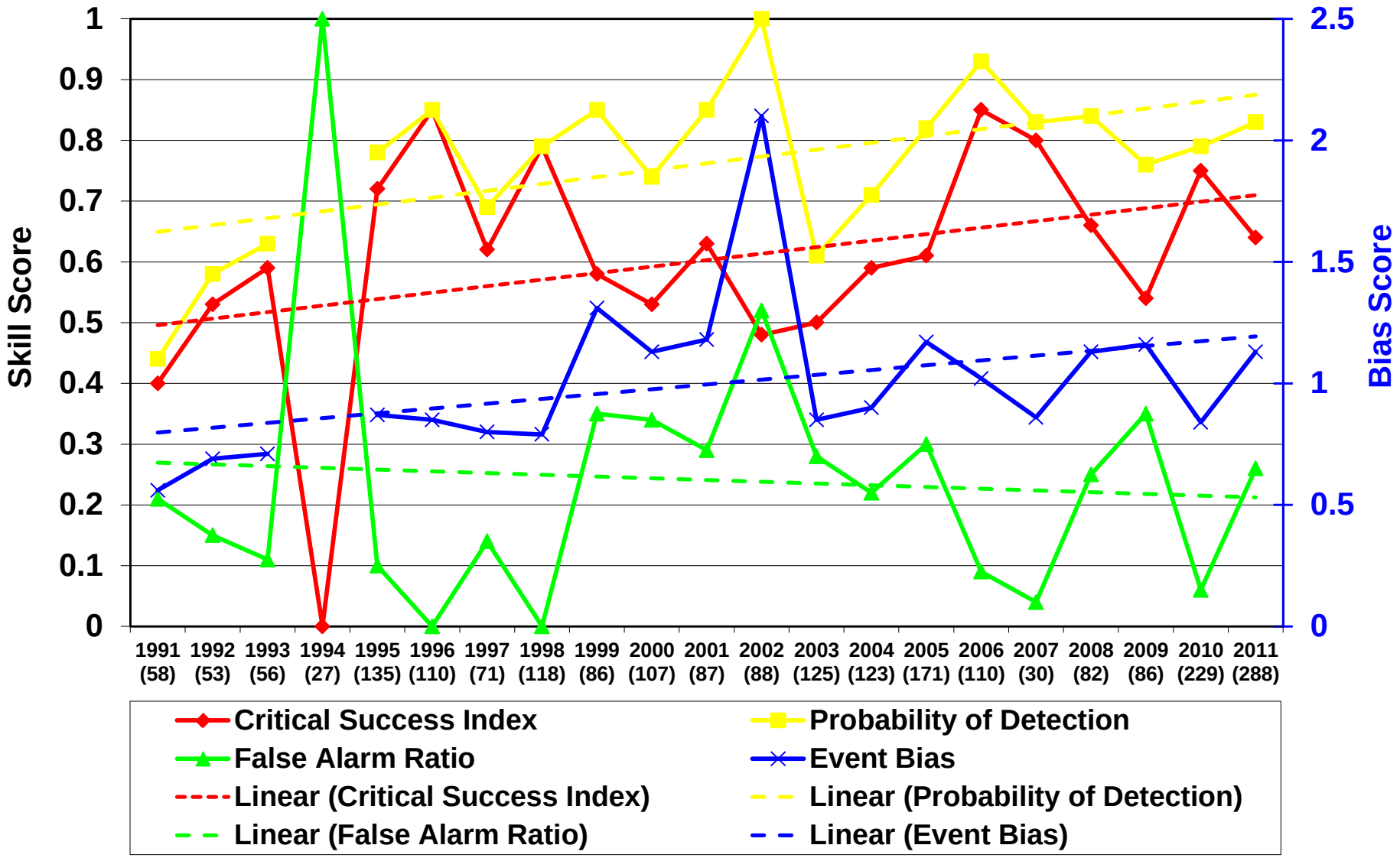
Mean ET Forecast Error (h)



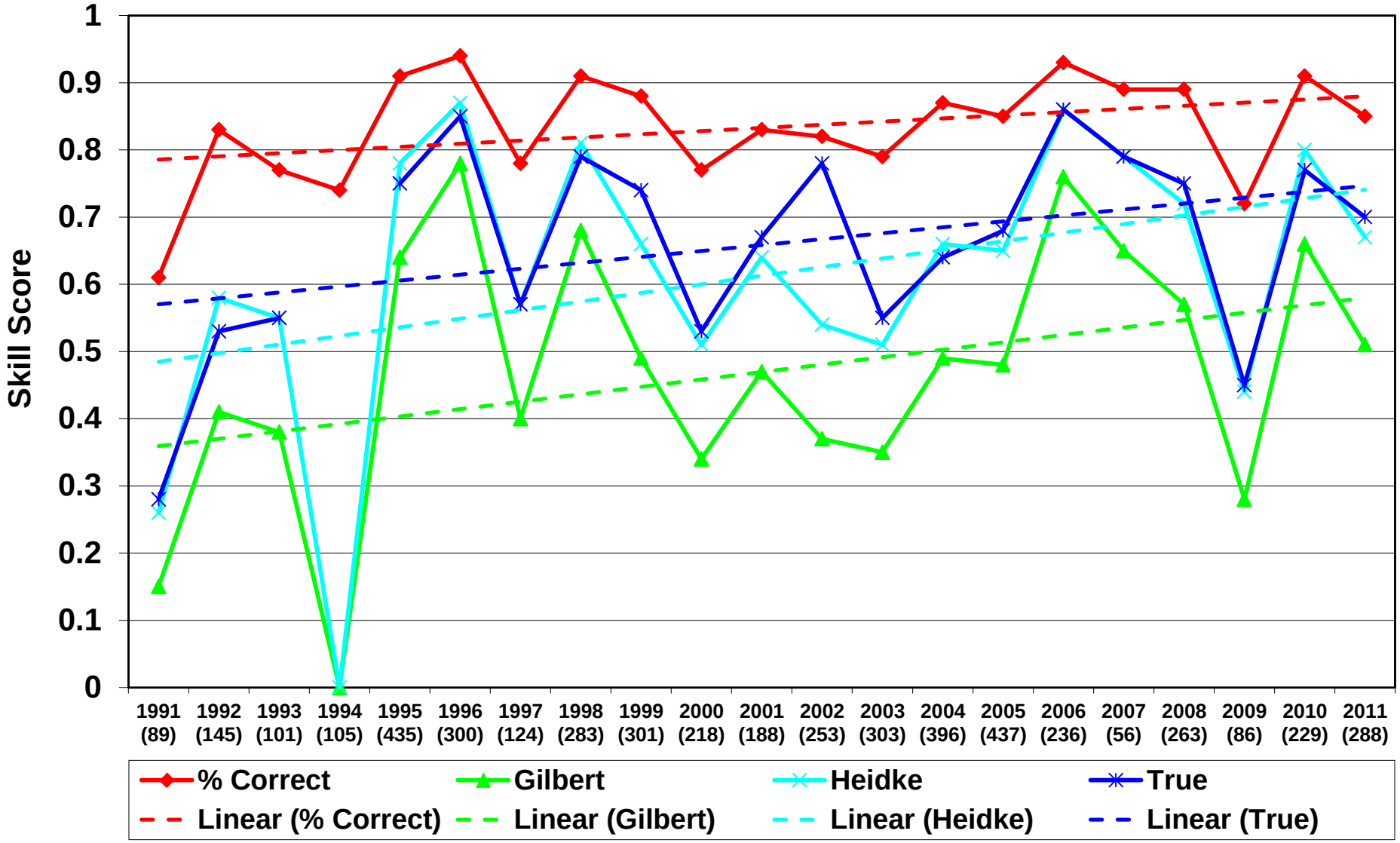
Mean ET Forecast Bias (h)



3-Day Potential ET Cases Only



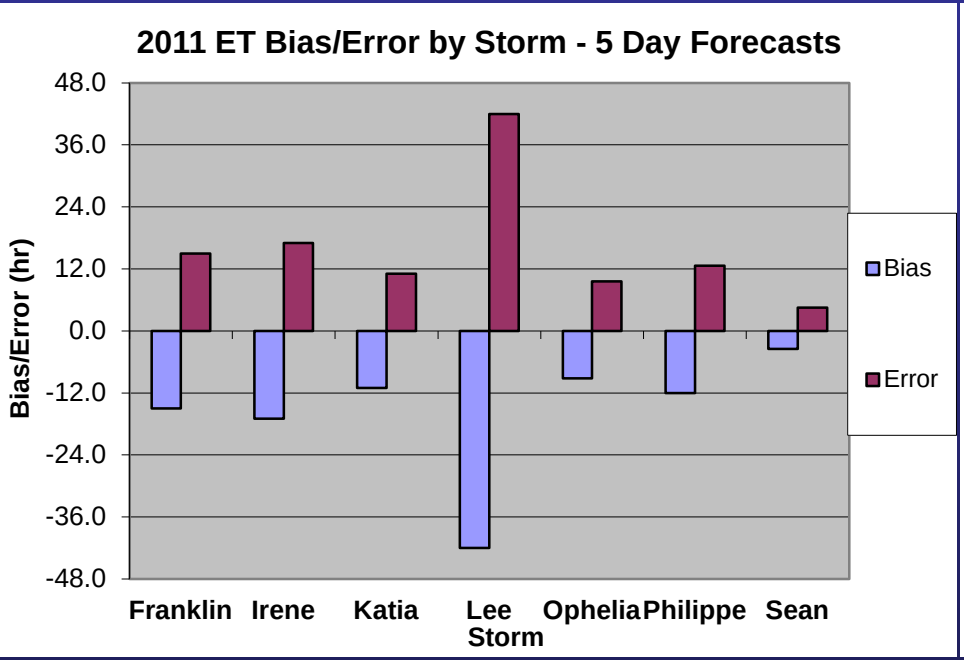
3-Day Potential ET Cases Only

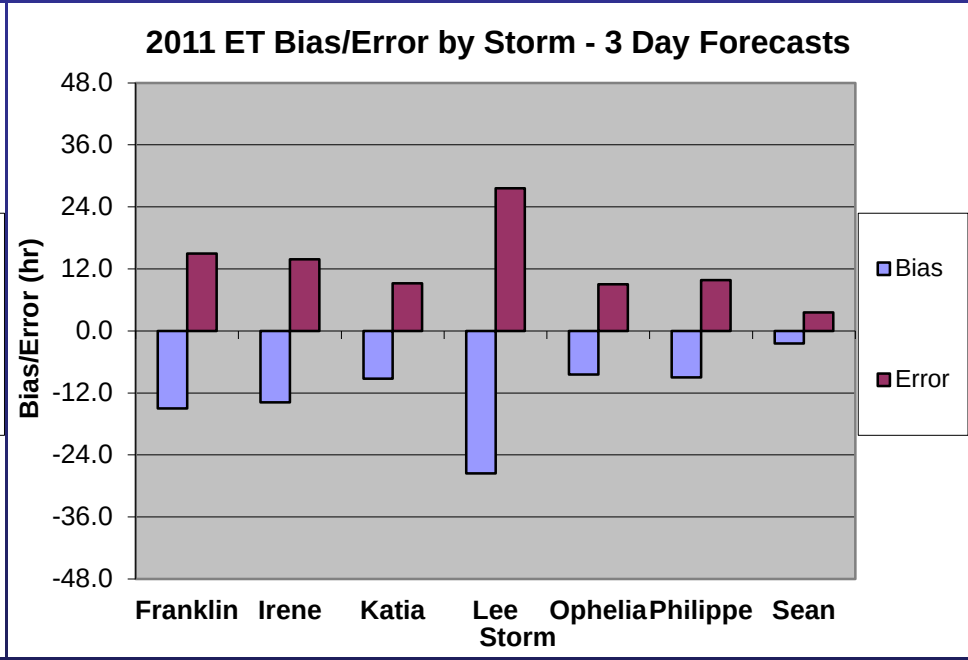


Meteorological Issues

- Systems that merged with fronts with the circulation completely dissipating: Cindy 1999, Harvey 1999?, Florence 2000, Cristobal 2002, Kyle 2002, TD14 2002, Irene 2005, Maria 2011
- Track forecast problems: Katrina 1999, Gamma 2005, Gordon 2006, Colin 2010, Irene 2011
- Intensity forecast problems: Mindy 2003, Bonnie 2004, Debby 2006
- Aborted transitions: Alberto 2000
- Slow or interrupted transitions: Gabrielle 2001, Maria 2005, Helene 2006
- Unclimatological transitions: Michelle 2001
- Unclimatological non-transitions: Humberto 2001, Juan 2003, Cindy 2011
- Transitions or lack thereof over mid-America: Lili 2002, Ivan 2004, Arlene 2005, Katrina 2005, Ike 2008
- Environmental mis-reads?: Henri 2003, Hermine 2004, Matthew 2004, Philippe 2005, Epsilon 2005, Tomas 2010, Gert 2011
- Unusual synoptic patterns: Lee 2011

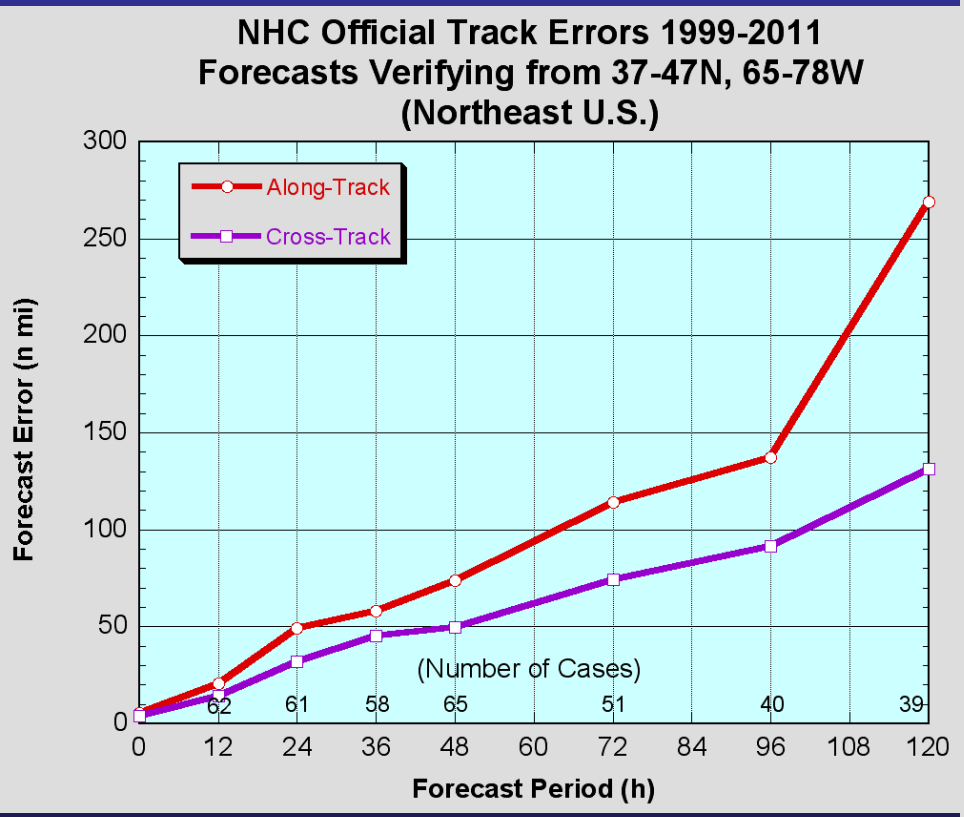
ET Timing Issues in 2011

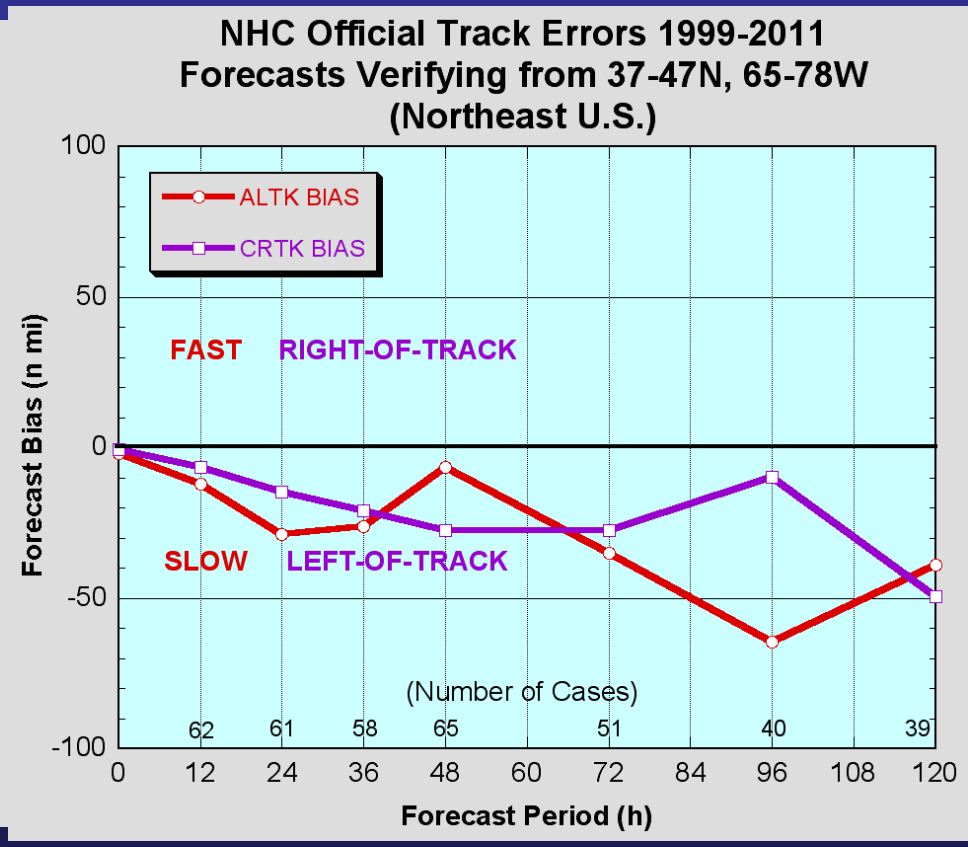




NHC forecasts of ET have a clear negative bias for every TC in 2011 that underwent ET – ET usually occurs earlier than NHC forecast. Why could this be happening?

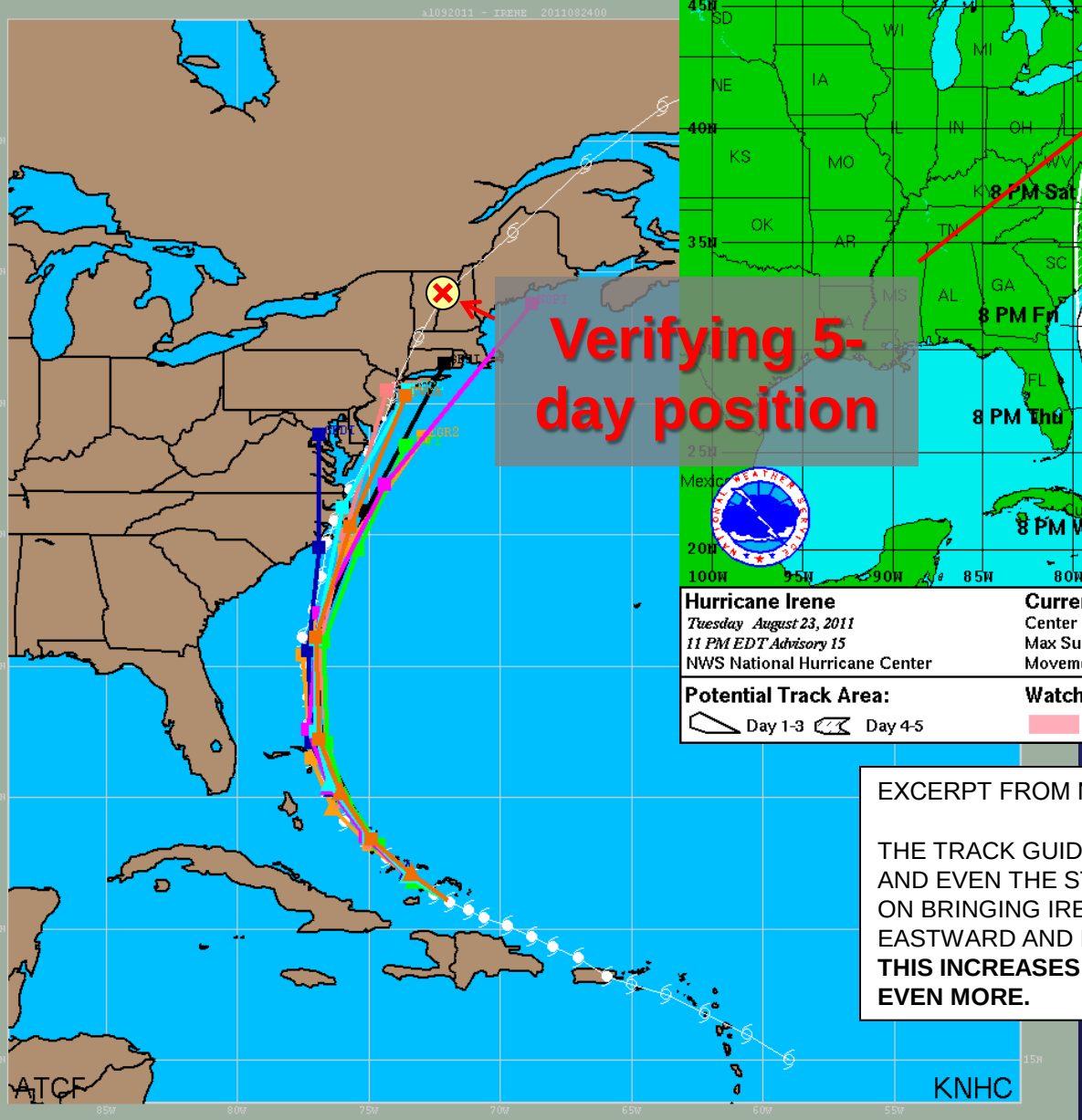
NHC Forecast Statistics near the Northeastern U. S.

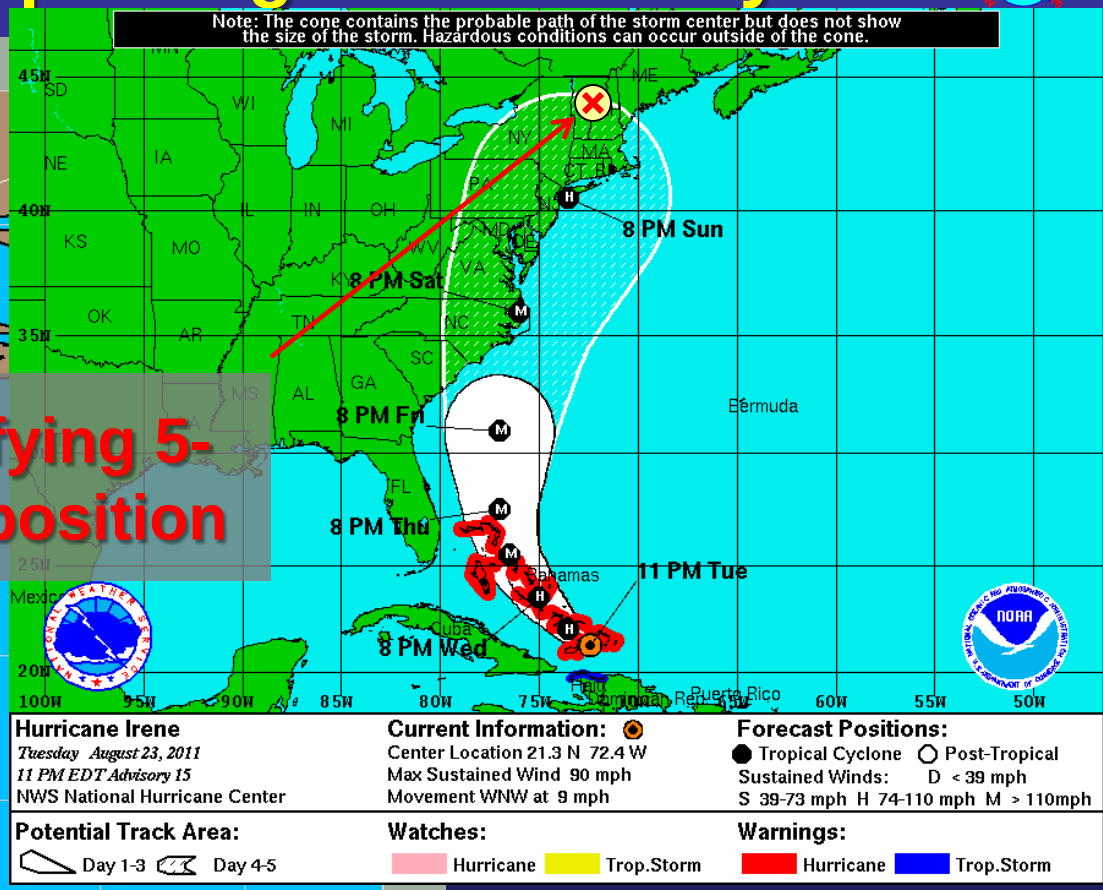




NHC track forecasts have a slow bias near the northeastern U. S. This is likely contributing to the errors in ET timing.

Irene Guidance 11 pm Aug 23 - Advisory #15

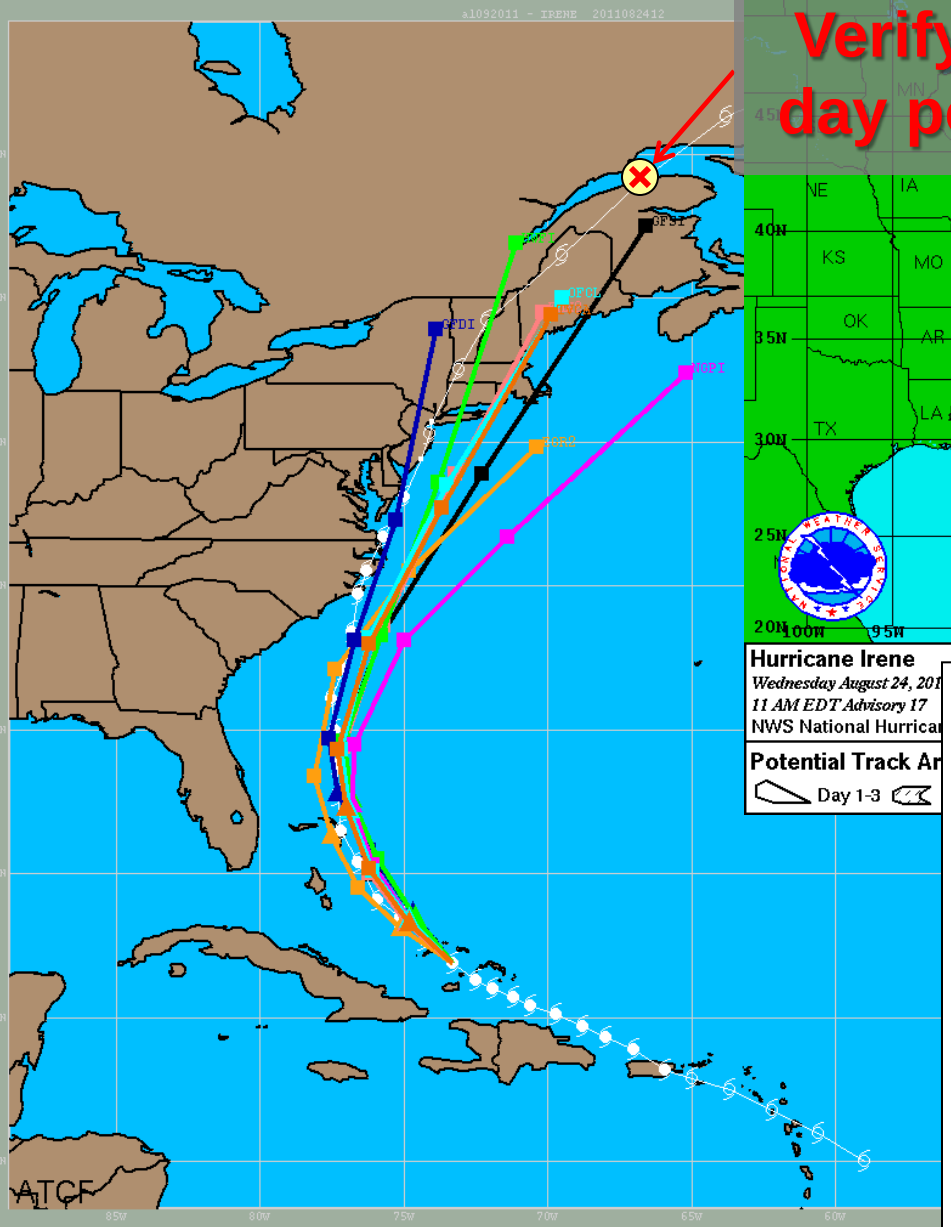


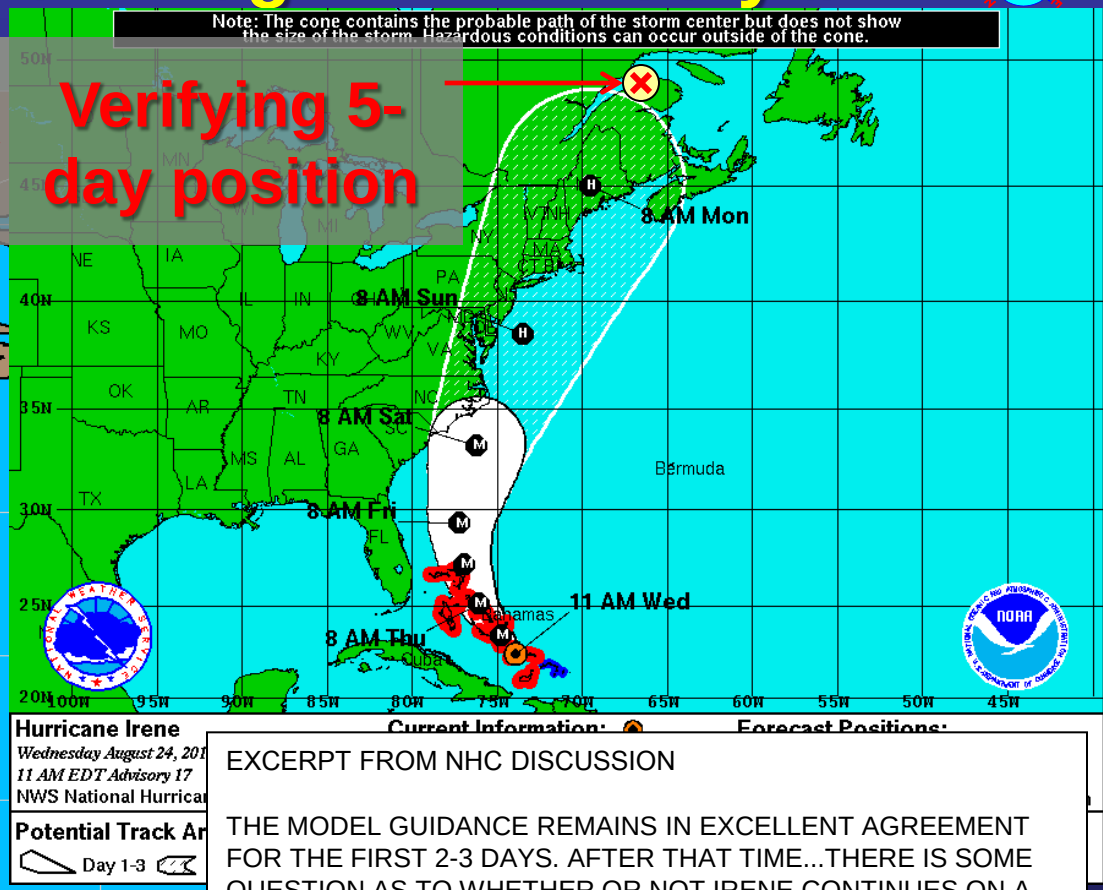


EXCERPT FROM NHC DISCUSSION

THE TRACK GUIDANCE IS IN BETTER AGREEMENT TONIGHT AND EVEN THE STUBBORN GFDL WHICH PREVIOUSLY INSISTED ON BRINGING IRENE TOWARD FLORIDA HAS NOW SHIFTED EASTWARD AND HAS JOINED THE OTHER DYNAMICAL MODELS. **THIS INCREASES THE CONFIDENCE IN THE TRACK FORECAST EVEN MORE.**

Irene Guidance 11 am Aug 24 - Advisory #17

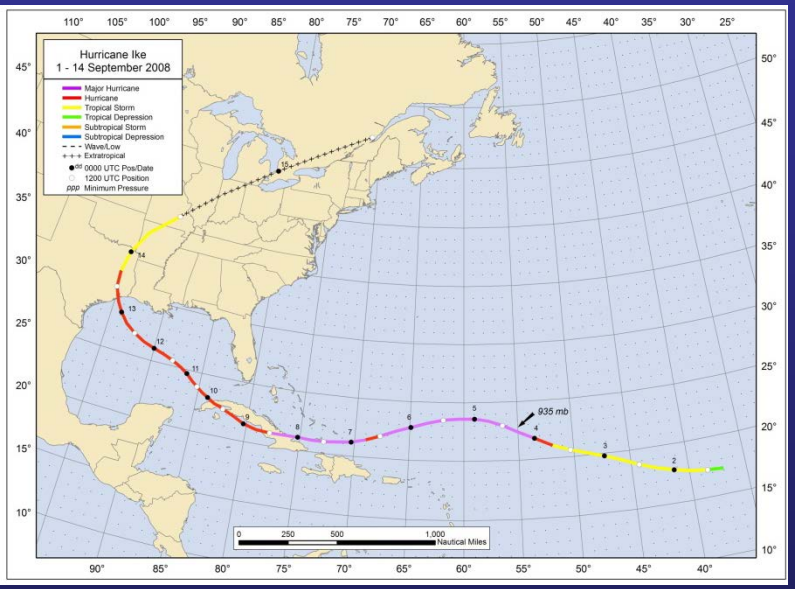


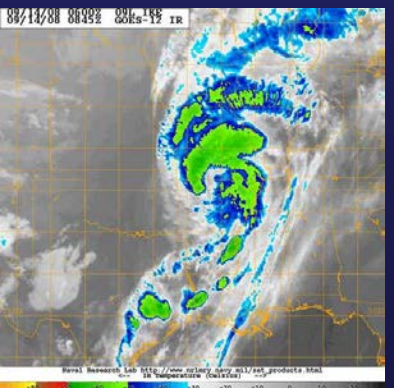


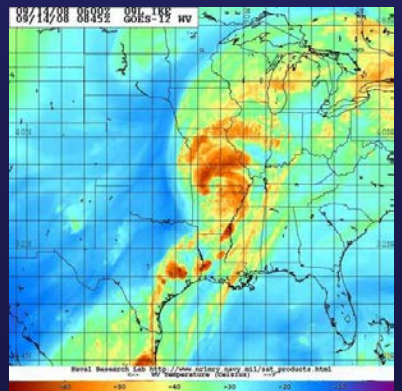
EXCERPT FROM NHC DISCUSSION

THE MODEL GUIDANCE REMAINS IN EXCELLENT AGREEMENT FOR THE FIRST 2-3 DAYS. AFTER THAT TIME...THERE IS SOME QUESTION AS TO WHETHER OR NOT IRENE CONTINUES ON A NORTH-NORTHEAST HEADING OR TURNS BACK TOWARD THE NORTH AHEAD OF A MID-LATITUDE TROUGH APPROACHING THE GREAT LAKES REGION. THE GFDL AND HWRF MODELS REMAIN ALONG THE WEST SIDE OF THE GUIDANCE ENVELOPE AND SHOW A TRACK OVER OR VERY CLOSE TO THE MID-ATLANTIC COAST. THE UKMET AND NOGAPS ARE ALONG THE EASTERN SIDE AND KEEP THE CORE OF THE HURRICANE WELL OFFSHORE. GIVEN THE TYPICAL MODEL AND OFFICIAL TRACK ERRORS...BOTH SCENARIOS ARE VIABLE OPTIONS AT THIS TIME...AND USERS ARE ONCE AGAIN REMINDED NOT TO FOCUS ON SPECIFIC FORECAST POINTS THREE TO FIVE DAYS DOWNSTREAM.

The ET of Ike (2008)







TROPICAL DEPRESSION IKE DISCUSSION NUMBER 53
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL092008
500 AM EDT SUN SEP 14 2008

SURFACE OBSERVATIONS INDICATE THAT IKE WEAKENED TO A TROPICAL DEPRESSION DURING THE PAST SEVERAL HOURS...WITH 25 TO 30 KT WINDS AND HIGHER GUSTS OCCURRING WELL TO THE SOUTHEAST OF THE CENTER. THE SURFACE DATA SHOW A COLD FRONT IS APPROACHING IKE...WITH AN AREA OF 25-35 KT WINDS DEVELOPING BEHIND THE FRONT FROM SOUTHWESTERN MISSOURI ACROSS NORTHWESTERN ARKANSAS INTO EASTERN OKLAHOMA. THIS IS THE FIRST SIGN OF EXTRATROPICAL TRANSITION...AND IT IS EXPECTED THAT IKE WILL LOSE TROPICAL CHARACTERISTICS DURING THE NEXT 24 HOURS AS IT MERGES WITH THE FRONT. SOME RE-INTENSIFICATION IS EXPECTED AFTER EXTRATROPICAL TRANSITION IS COMPLETE...WITH IKE PRODUCING GALE-FORCE WINDS UNTIL IT MERGES WITH A LARGER LOW IN ABOUT 72 HR.

THE INITIAL MOTION IS NOW 045/26. IKE IS EXPECTED TO ACCELERATE TOWARD THE NORTHEAST DURING THE NEXT 24 HOURS...AND THEN CONTINUE RAPIDLY NORTHEASTWARD UNTIL THE SYSTEM MERGES WITH THE LARGER LOW AT VERY HIGH LATITUDE.

THIS IS THE LAST ADVISORY ON IKE FROM THE NATIONAL HURRICANE CENTER. FUTURE ADVISORIES WILL BE ISSUED BY THE HYDROMETEOROLOGICAL PREDICTION CENTER IN WASHINGTON DC.

FORECAST POSITIONS AND MAX WINDS

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INITIAL      14/0900Z 36.4N  92.5W    30 KT...INLAND
 12HR VT     14/1800Z 40.4N  87.0W    30 KT...BECOMING EXTRATROPICAL
 24HR VT     15/0600Z 45.6N  76.5W    35 KT...INLAND EXTRATROPICAL
 36HR VT     15/1800Z 50.0N  65.3W    40 KT...EXTRATROPICAL
 48HR VT     16/0600Z 55.0N  52.5W    40 KT...EXTRATROPICAL
 72HR VT     17/0600Z...MERGED WITH LARGER LOW
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FORECASTER BEVEN

Ike (2008) and the Windstorm over Ohio

Jay Hobgood and Nick D’Allura
Ohio State University

May 12, 2010

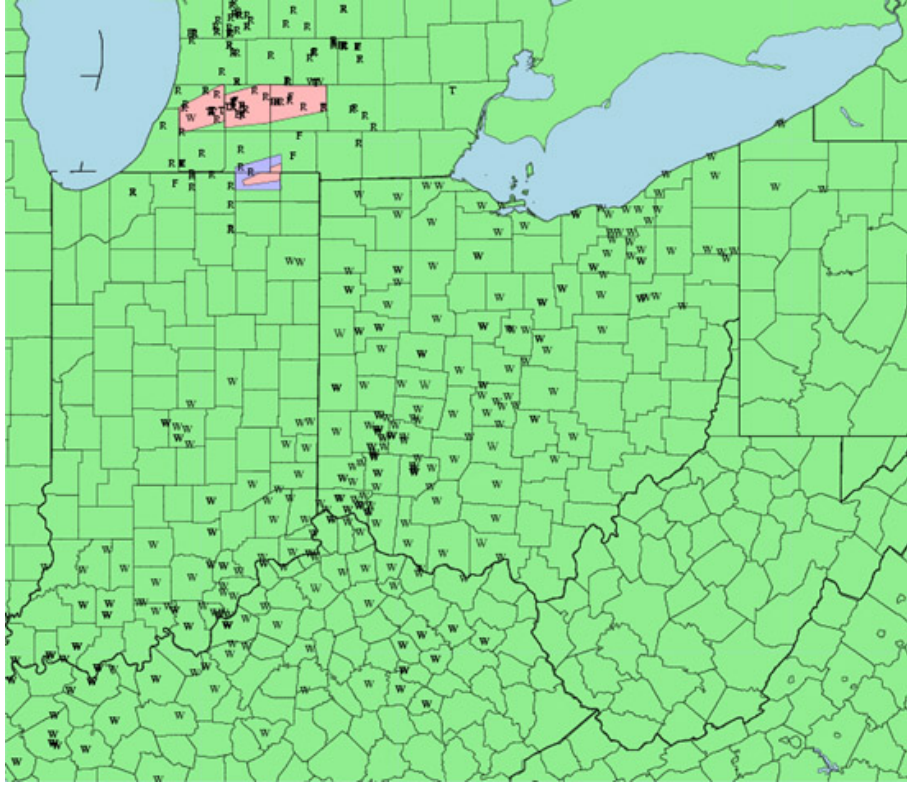
Impacts from ET Ike

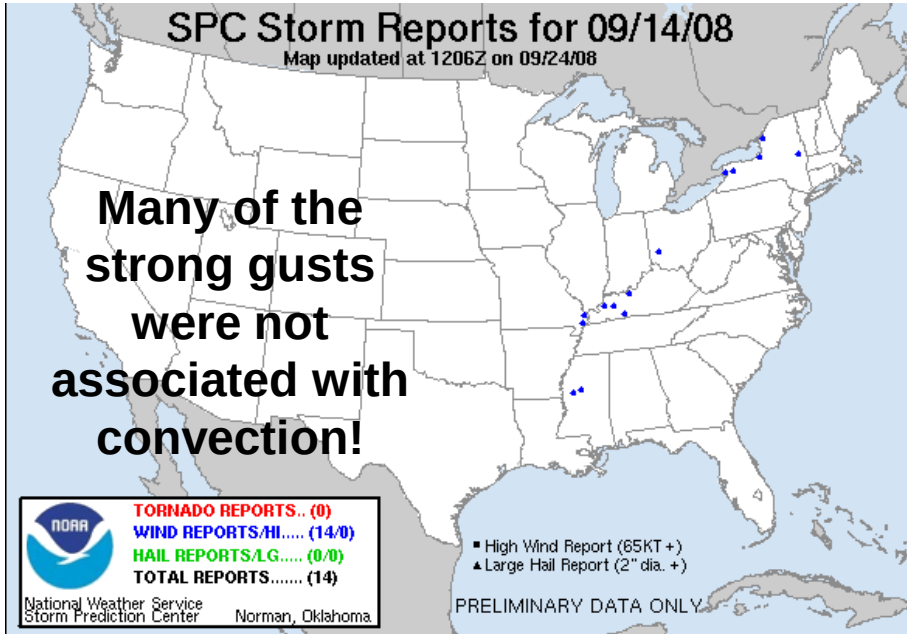
- Strong wind gusts from Missouri through the Ohio Valley into southern Ontario and Québec, primarily <u>not</u> associated with convection
- $2.3 billion in property damage in this area
- Millions of people without power for days to weeks
- 28 deaths from various causes

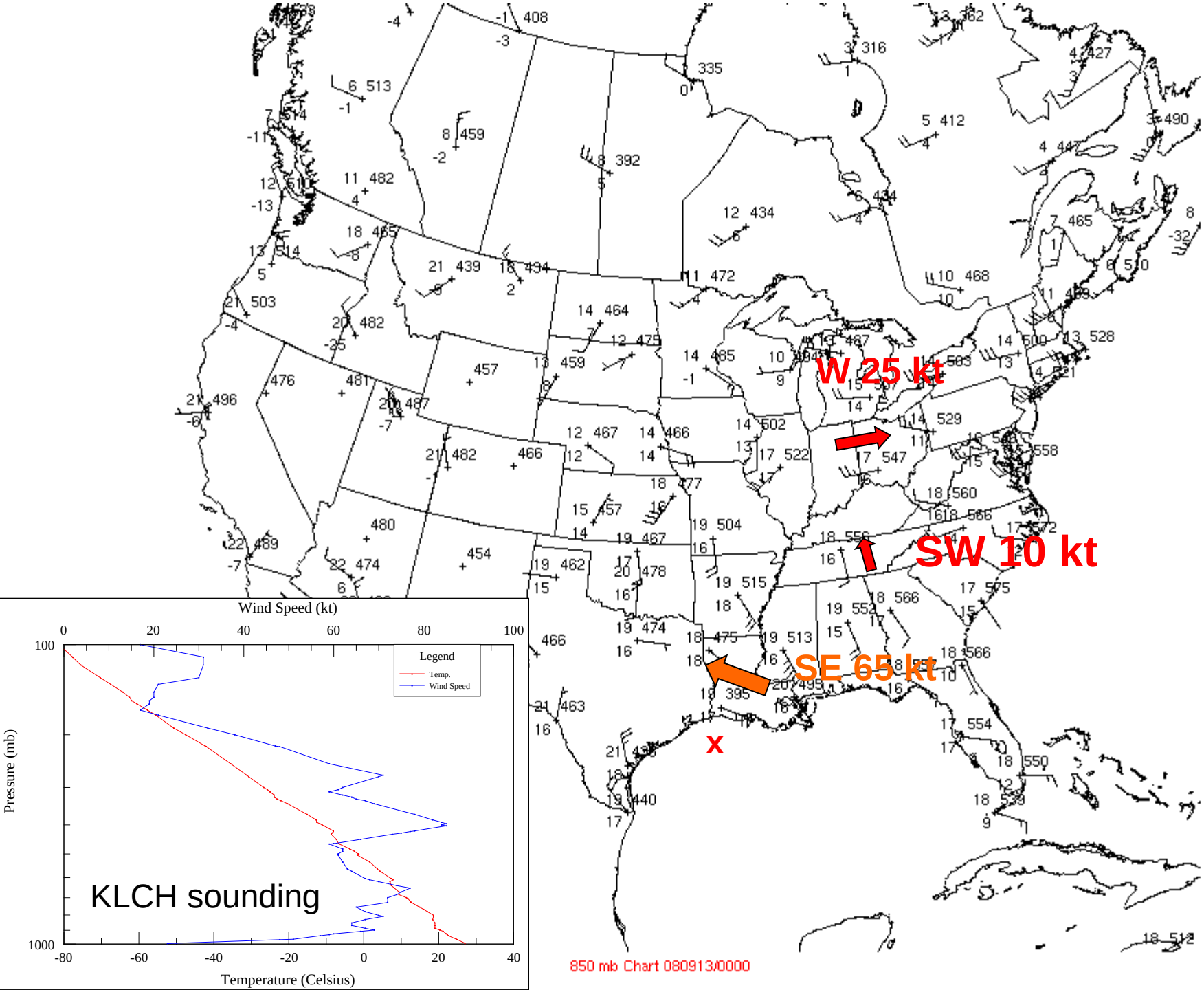
Source: Louisville NWSFO Photo: Mike Howard (from Jay's presentation)

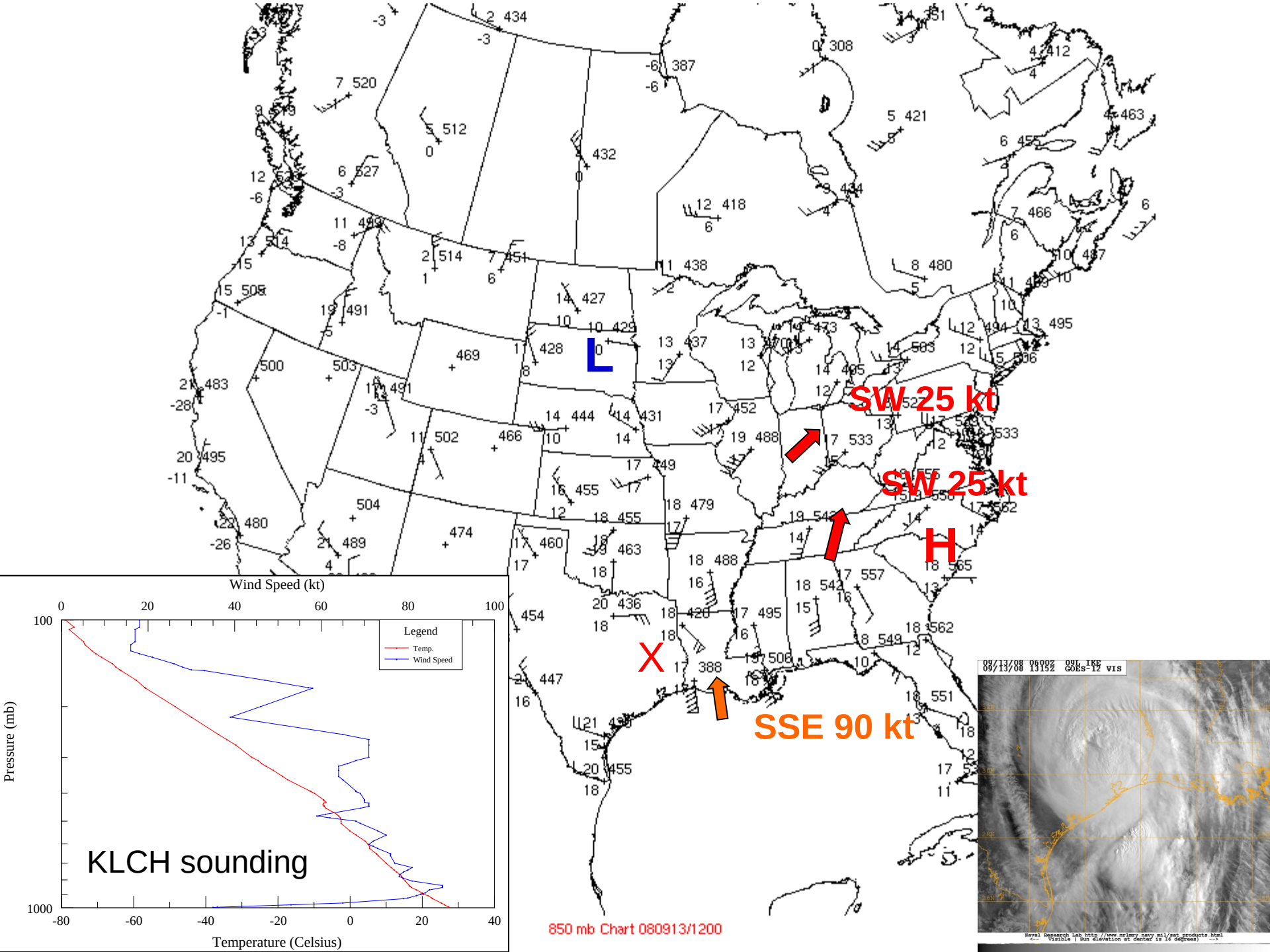
Highest Measured Wind Gusts (Official Observations)

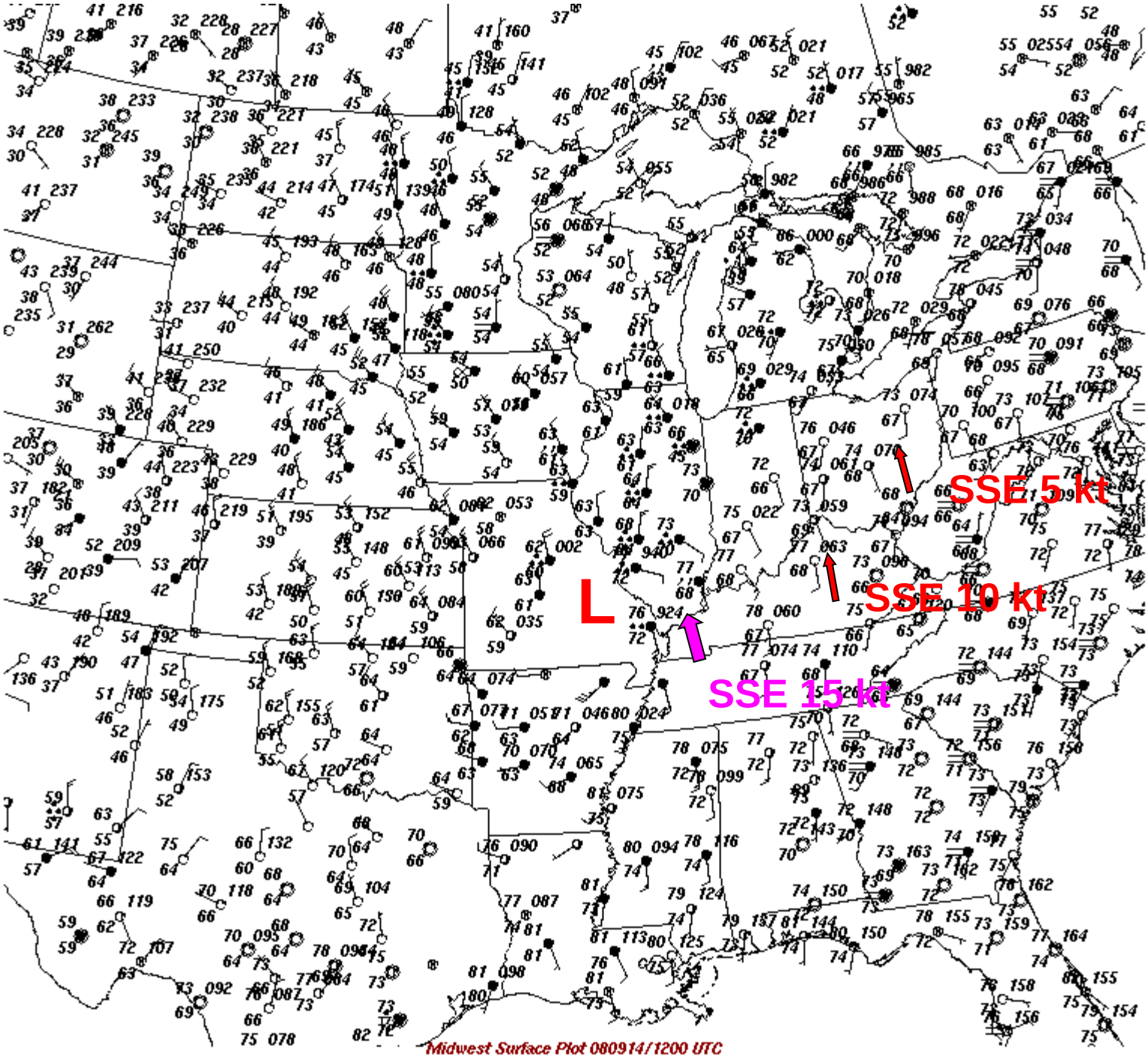
- 75 m.p.h. – Port Columbus International, OH and Louisville, KY
- 74 m.p.h. – Cincinnati-Northern KY Airport and Airborne Airpark, Wilmington, OH
- 71 m.p.h. – Lorain, OH
- 69 m.p.h. – Bolton Field, OH and Beaver Fallls, PA
- 68 m.p.h. – Dayton-Wright Brothers Airport, OH
- 63 m.p.h. – Don Scott Field, OH
- 60 m.p.h. – Dayton International Airport
- 59 m.p.h. – Wright-Patterson Air Force Base, OH

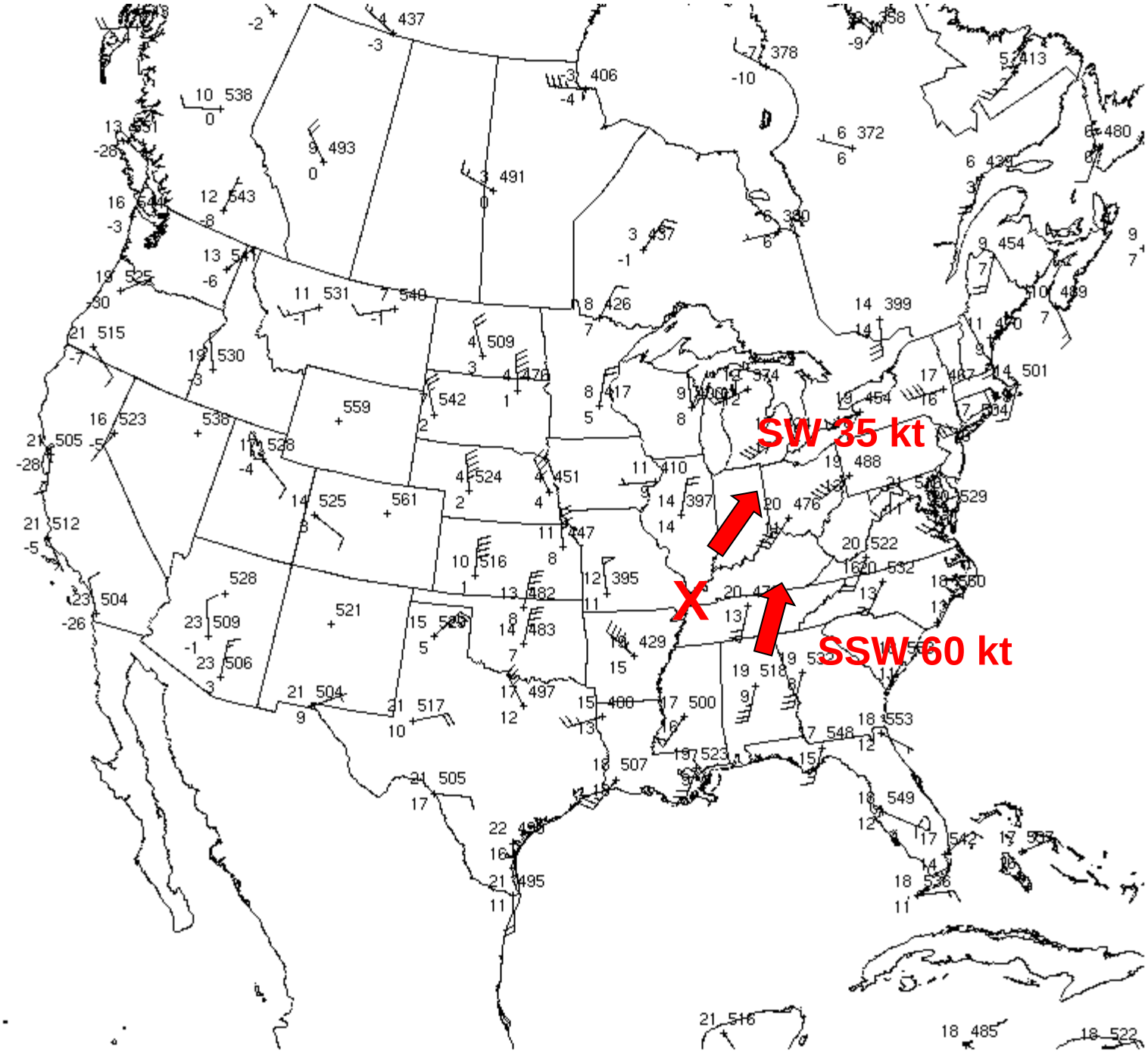




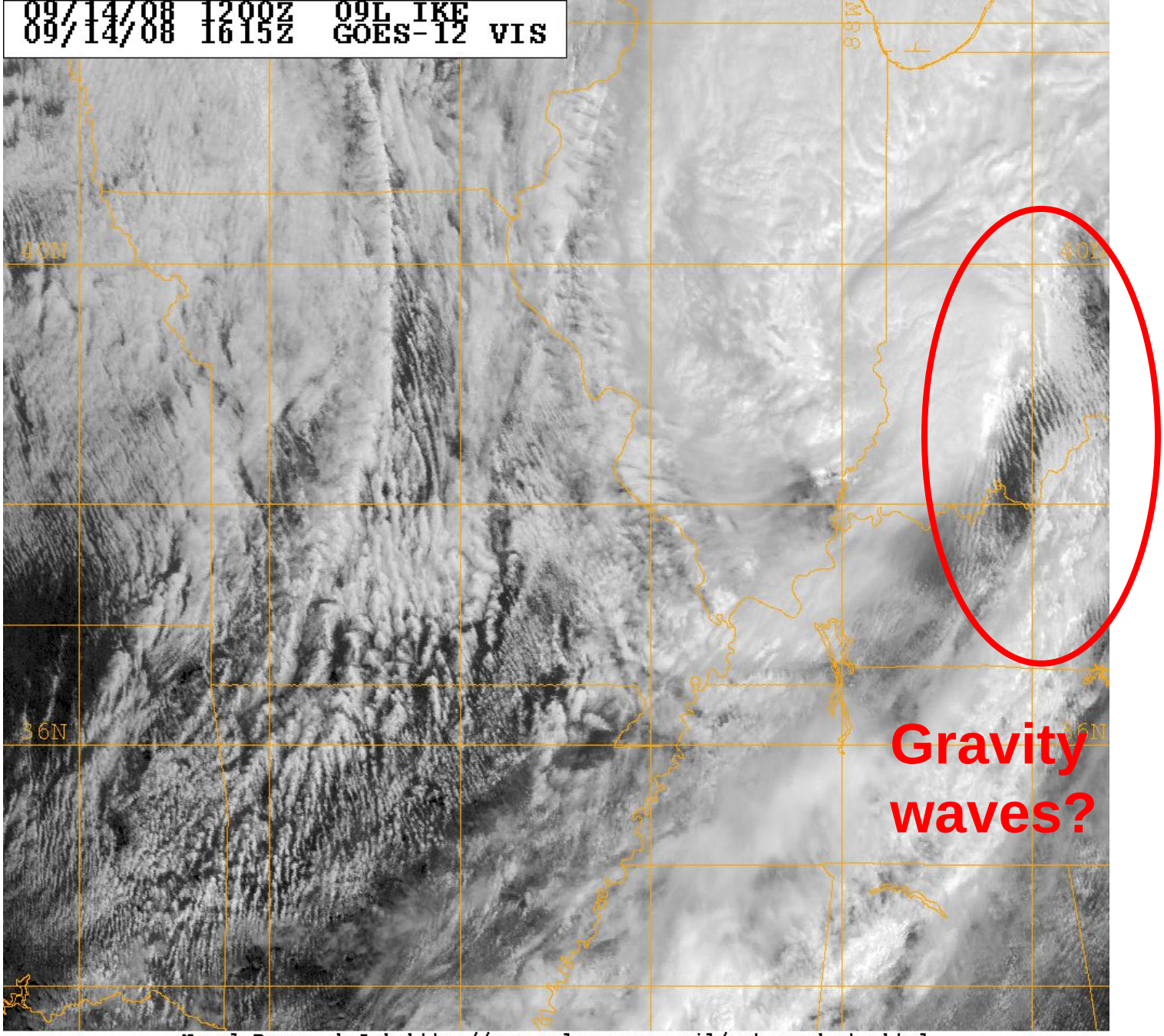

W 25 kt
SW 10 kt
SE 65 kt
X
850 mb Chart 080913/0000
Wind Speed (kt)
Pressure (mb)
Temperature (Celsius)
Legend
Temp.
Wind Speed
KLCH sounding


L
H
SW 25 kt
SW 25 kt
SSE 90 kt
X
850 mb Chart 080913/1200
Wind Speed (kt)
Pressure (mb)
Temperature (Celsius)
Legend
Temp.
Wind Speed
KLCH sounding
09/13/08 0600Z OGL IKE
09/13/08 1315Z GOES-12 VIS

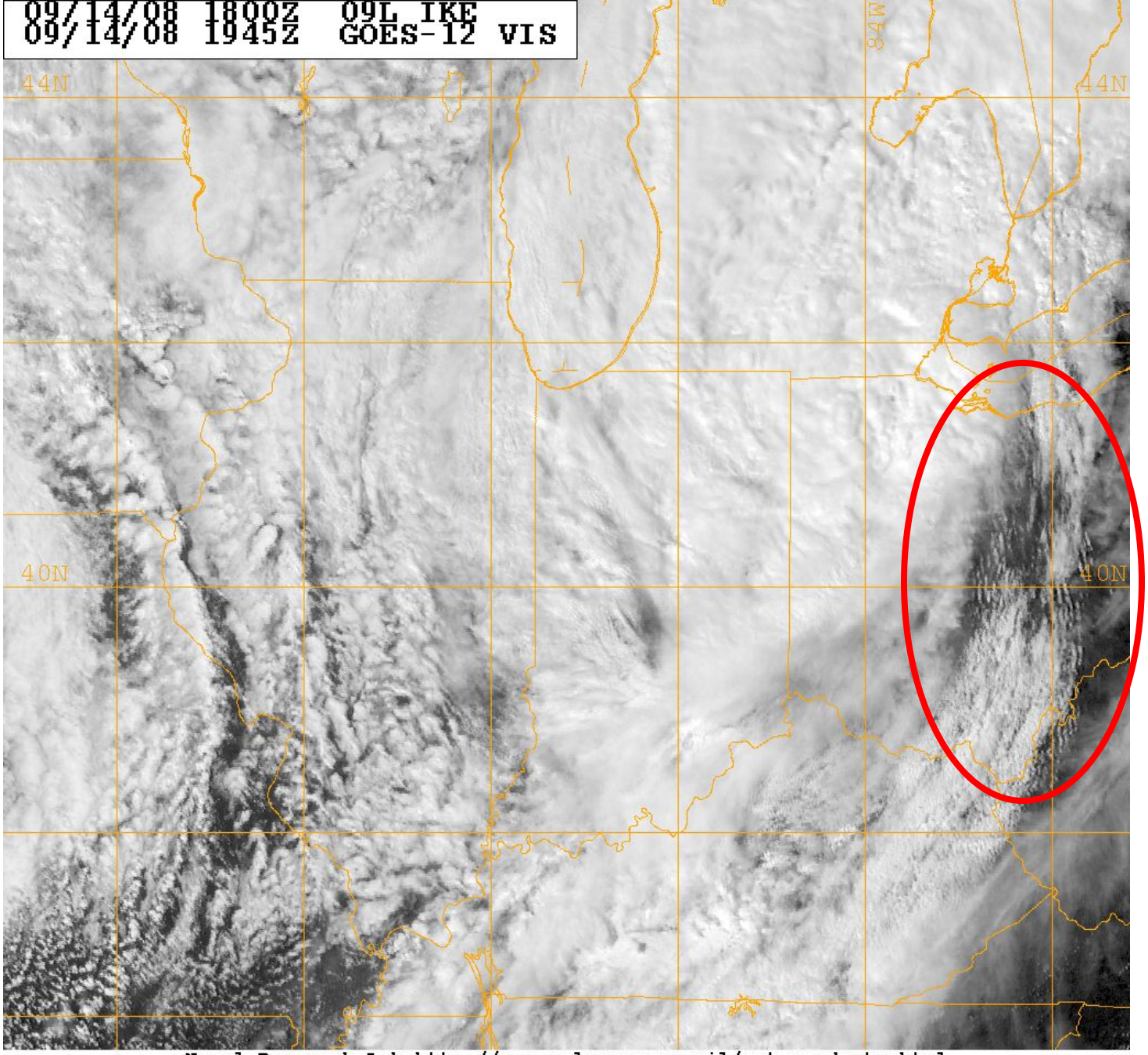

SSE 5 kt
SSE 10 kt
SSE 15 kt
L
Midwest Surface Plot 080914/1200 UTC



850 mb Chart 080914/1200



Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- Visible (Sun elevation at center is 48 degrees) -->



Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- Visible (Sun elevation at center is 43 degrees) -->

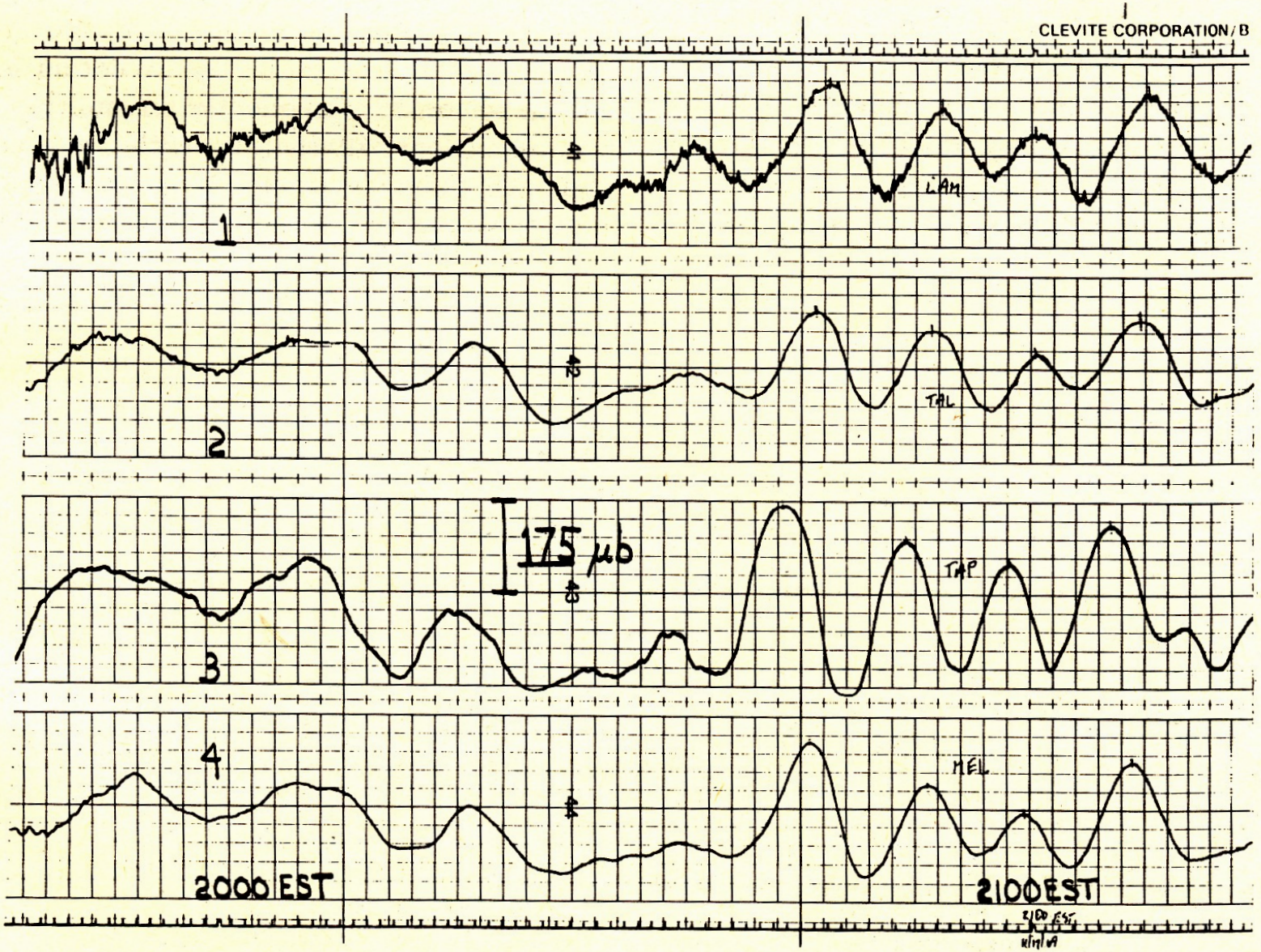
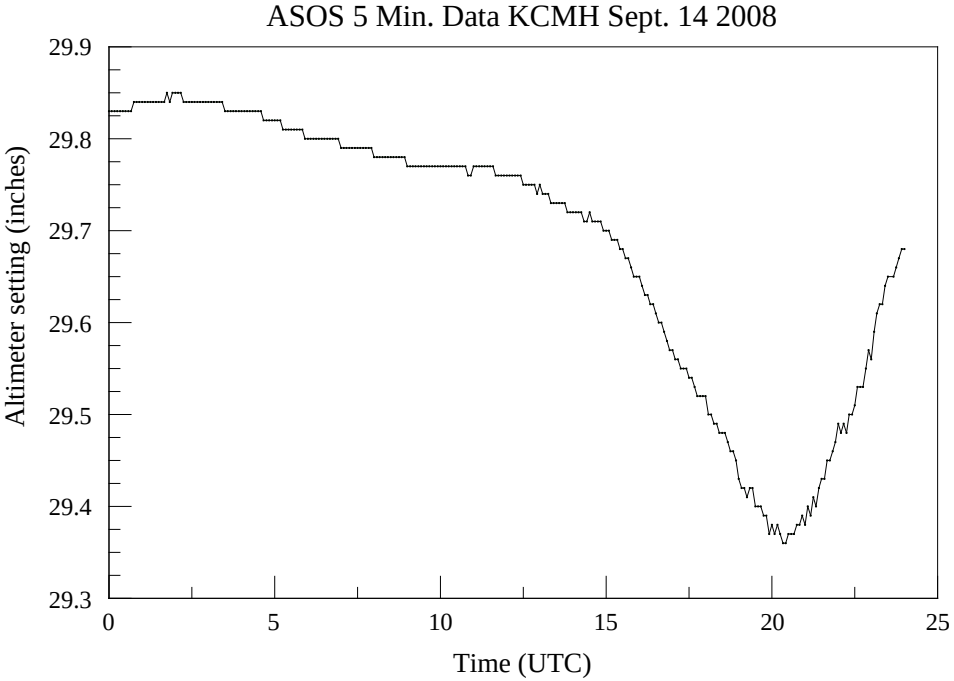
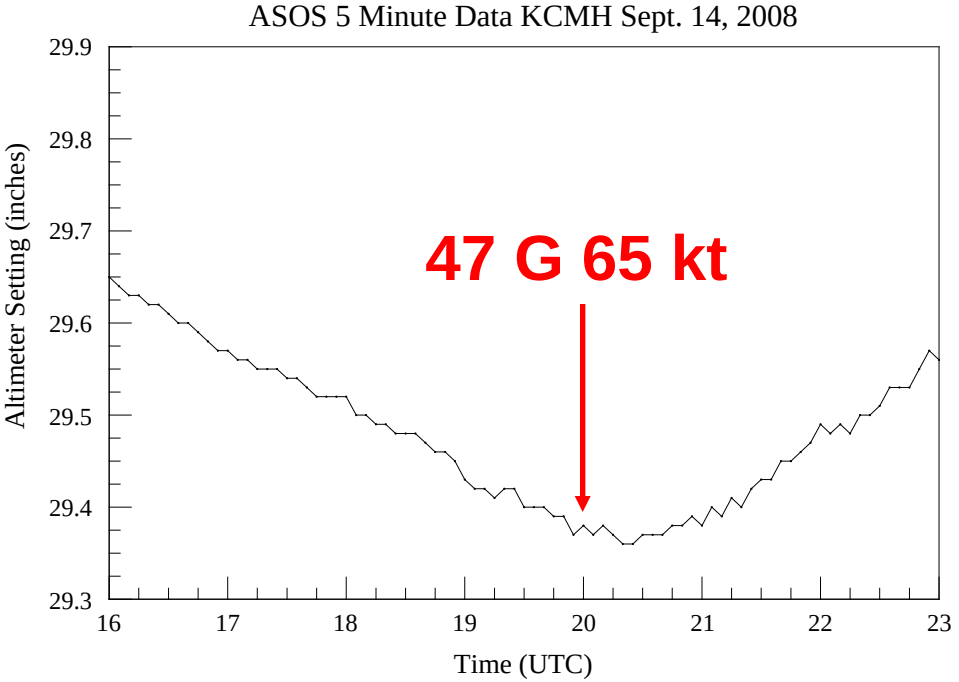
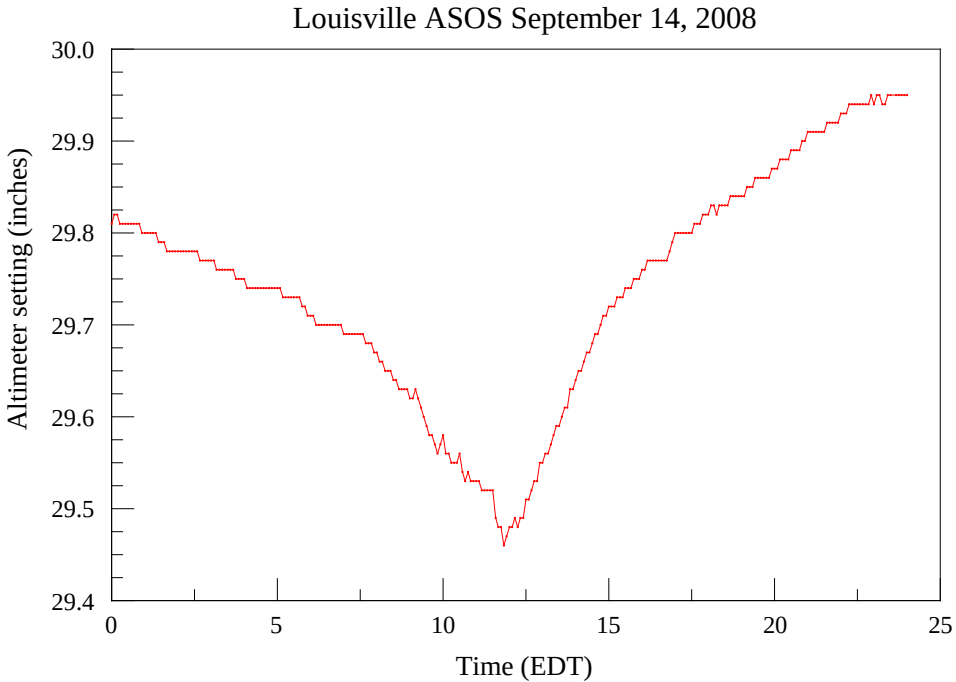


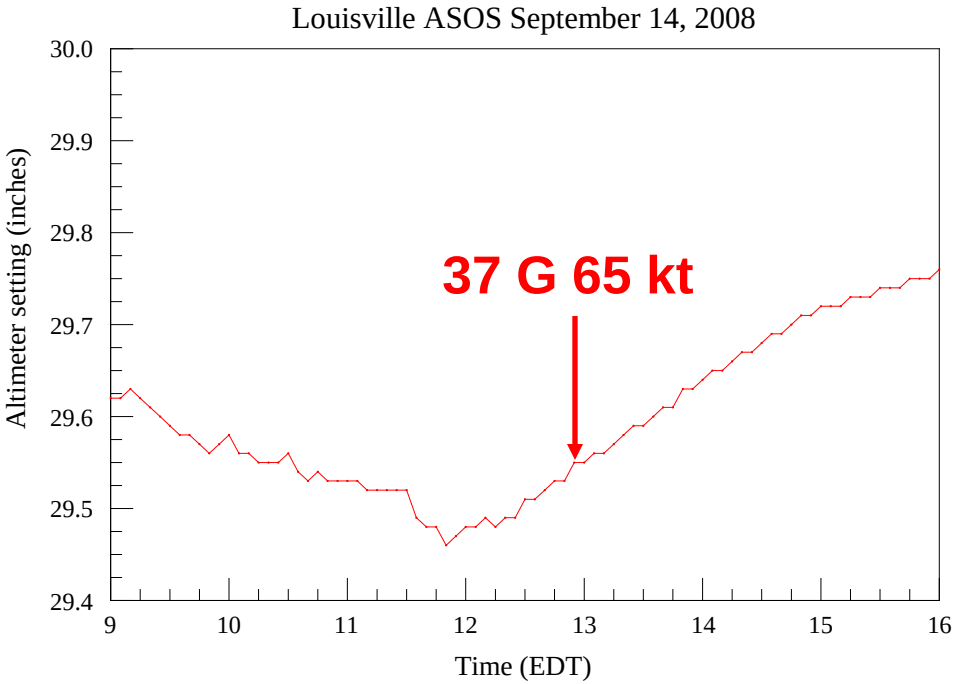
FIG. 1. Actual section of microbarovariograph record for four different stations located around Lamont. Time runs from left to right covering more than 1 h. Maximum pressure variation is 350 μb.

Source: Gedzelman and Rilling (1978)

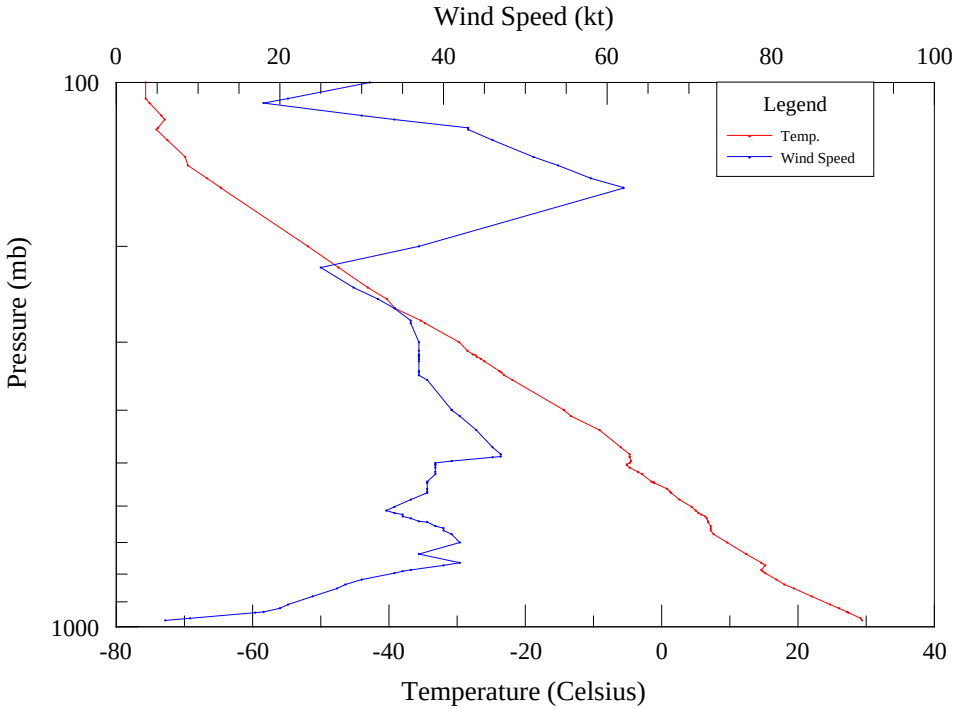

ASOS 5 Min. Data KCMH Sept. 14 2008
Altimeter setting (inches)
29.9
29.8
29.7
29.6
29.5
29.4
29.3
0
5
10
15
20
25
Time (UTC)


ASOS 5 Minute Data KCMH Sept. 14, 2008
47 G 65 kt
Altimeter Setting (inches)
29.9
29.8
29.7
29.6
29.5
29.4
29.3
16
17
18
19
20
21
22
23
Time (UTC)

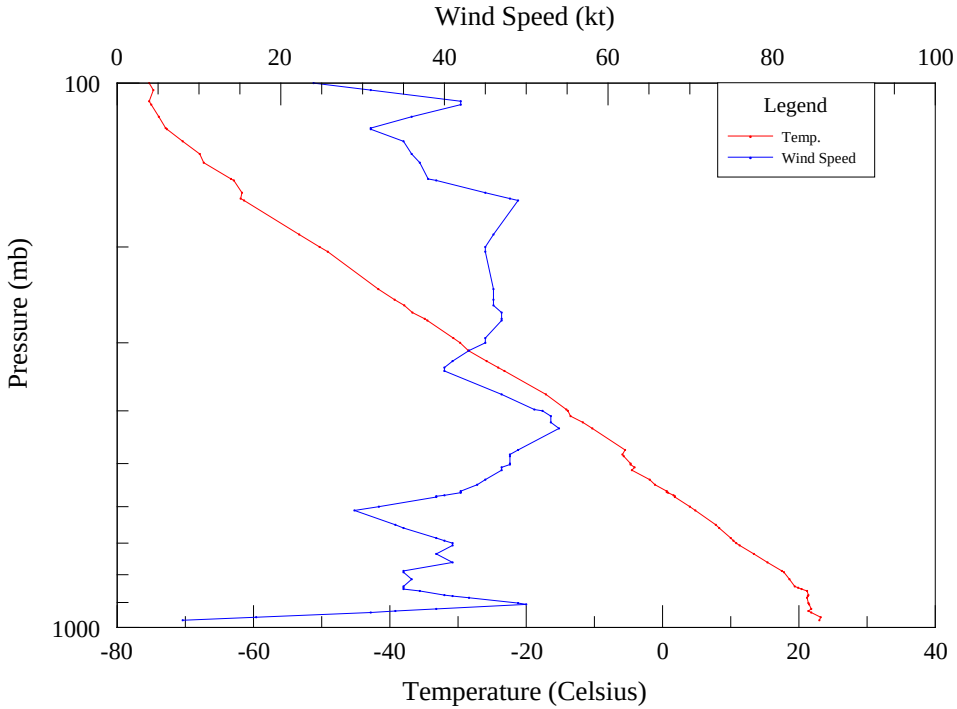

Louisville ASOS September 14, 2008
Altimeter setting (inches)
30.0
29.9
29.8
29.7
29.6
29.5
29.4
0
5
10
15
20
25
Time (EDT)


Louisville ASOS September 14, 2008
37 G 65 kt
Altimeter setting (inches)
30.0
29.9
29.8
29.7
29.6
29.5
29.4
9
10
11
12
13
14
15
16
Time (EDT)

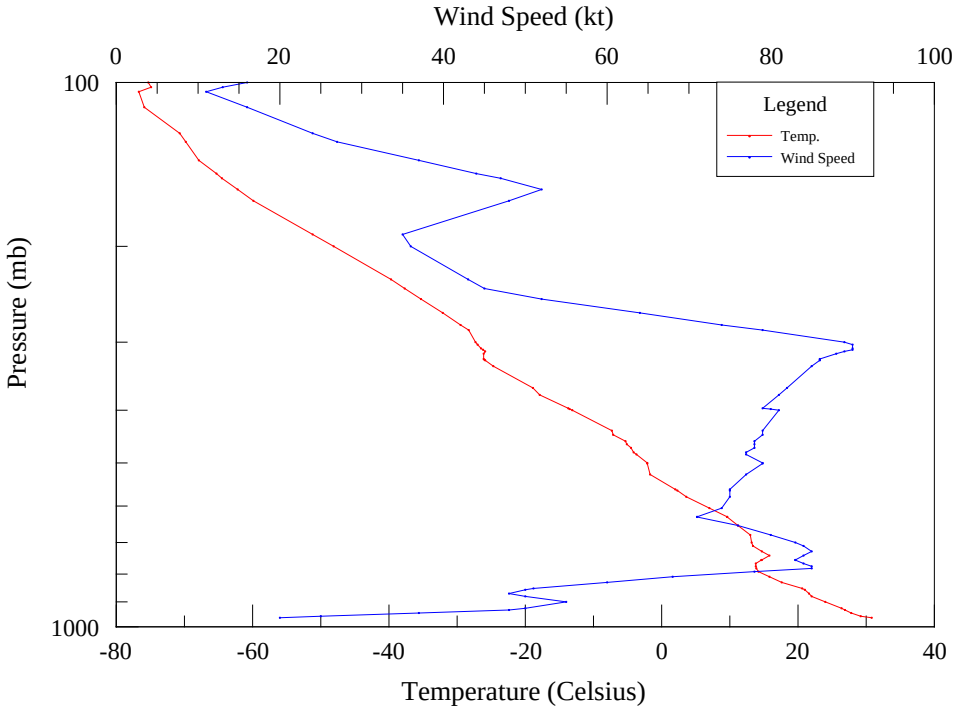
Wilmington, OH 0000 UTC September 14, 2008



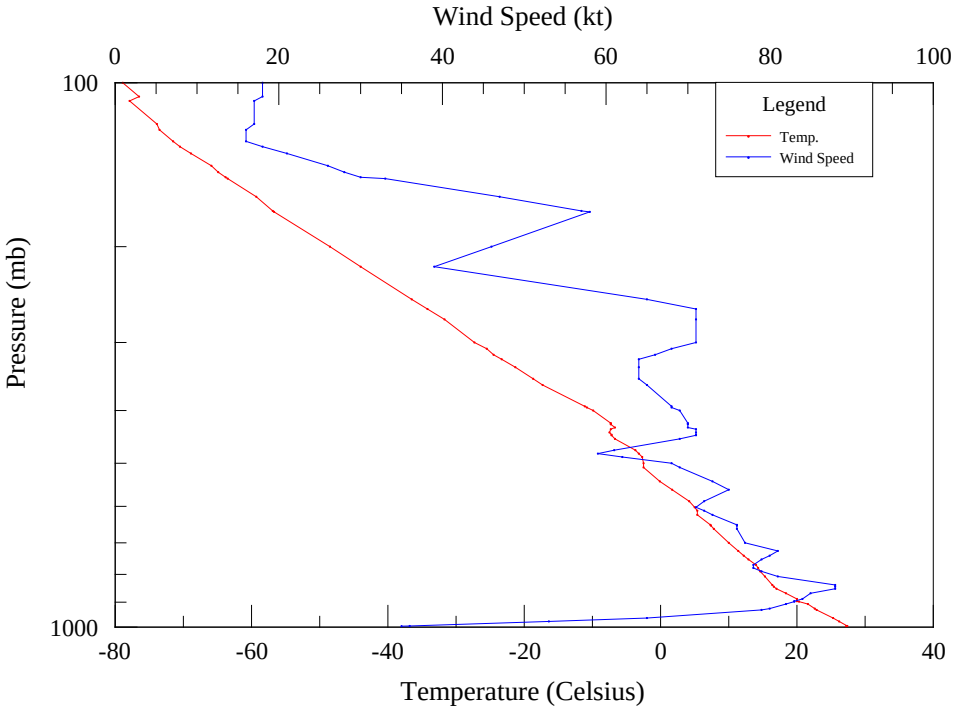
Wilmington, OH 1200 UTC September 14, 2008



Wilmington, OH 1800 UTC September 14, 2008



Lake Charles, LA 1200 UTC September 13, 2008



Possible Causes of Gravity Waves

1. Convection
2. Density impulses
3. Unbalanced jet streaks
4. Strong frontal systems
5. Topography
6. Vertical shear instability

Factors Contributing to High Winds

1. Ike made landfall as a large hurricane
2. Ike contained much higher winds just above the surface.
3. Limited rainfall did not produce downdrafts that would have mixed down the winds earlier (farther south)
4. Mechanical mixing possibly caused by gravity waves brought higher wind speeds down to the surface.
5. The wavelength of the gravity waves was 10-20 km.
6. The gravity waves may have resulted from a combination of vertical shear, frontal processes and convection.
7. An inversion near the 700 mb level may have helped to maintain the gravity waves.

Work Left to Do

1. Determine the location where the gravity waves originated.
2. Identify the precise cause of the gravity waves.
3. *How much did Ike re-intensify, and how much of the winds were due to changes in vertical mixing? (JLB question)*

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- NWS Wilmington web site and storm summary
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Conclusions

- NHC forecasts of extratropical transition show skill according to the metrics of the 2-D contingency table verification
- ET forecasts have shown a general increase in skill since 1991. This is likely due to better NWP models, as well as use of the Hart and Evans Cyclone Phase Space diagrams.
- The NHC forecasts currently have a persistent bias of being too late – transition often occurs before the time it is forecast. In the Irene (2011) case, this resulted from slow track forecasts.
- As shown by the Ike case, incorrect forecasts of meteorological parameters during and after ET can cause problems!