Weather and Climate: From Data to Decision

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Kentucky Climate Center
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Nature's Call to Action
Kentucky's 2012 Regional Conference
Kentucky Transportation Cabinet

March 27, 2012

Weather and Climate Matter

- Growing population and a growing economy
- Societal expectations of mobility
- An economic system based on just-in-time shipping
- Intensity of economic competition on a global scale
- The challenge and opportunity of uncertainty

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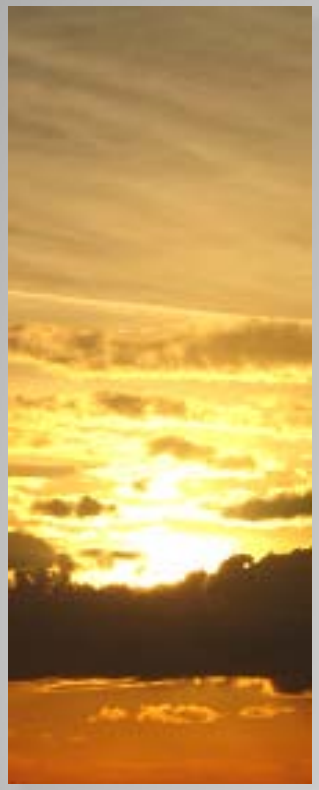
Kentucky's Climate Extremes
Summer Heat



- Greensburg, Green County, reached 114 F on July 28, 1930.
- Lovelaceville, Ballard County, experienced 30 days with temperatures reaching 100 F during the summer of 1930.
- Hopkinsville, Christian County, suffered through14 consecutive days with temperatures at or above 100 F from August 27 through September 9, 1925.
- Kentucky's hottest summer was 1936.

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Kentucky's Climate Extremes
Winter Chill

- Shelbyville set a statewide record of -37 F on January 19, 1994.
- Blasts of frigid Arctic air in January of 1963 and February of 1951 left temperatures from -20 F to lower than -30 F
- Gray Hawk recorded below zero temperatures on 23 mornings during the winter of 1976-77.
- Farmers reported sub-zero temperatures on 24 mornings during the winter of 1917-18.

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Kentucky Climate Extremes
Wet and Dry

- Kentucky can become extremely wet
  - Caneyville, 88.07 inches of precipitation, 1979
  - Earlington, 22.97 inches of precipitation, January 1937
  - Scottsville, 8.85 inches of rain fell in six hours, June 23, 1969
  - Statewide, 2011 was the wettest year on record

- Kentucky can become extremely dry
  - Jeremiah, 14.51 inches of precipitation for the year of 1968
  - Murray, 45 consecutive days without a trace of rainfall between Sep 14 and Oct 31, 1963

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The Anchor: From Data to Decision

Data

- Weather observations

Information

- Graphical & statistical summaries

Knowledge

- Enhanced understanding of weather, climate, and impacts

Decision

- Effective use of resources

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Questions

- What is the difference between weather and climate?
- If we can't forecast the weather more than a few days ahead, how can we possibly predict what the climate will be decades into the future?
- Last winter was cold and snowy. This winter was, well we didn't really have one. Why is our climate so variable from year to year?
- So they say that our climate is changing, but how would we recognize change if we saw it?

- Enhanced understanding of weather, climate, and impacts

Knowledge

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Contrasting Weather and Climate

NASA

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time. (http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html)

University Corporation for Atmospheric Research

Weather is the mix of events that happen each day in our atmosphere including temperature, rainfall and humidity. … Climate is the average weather pattern in a place over many years. (http://www.eo.ucar.edu/basics/index.html)

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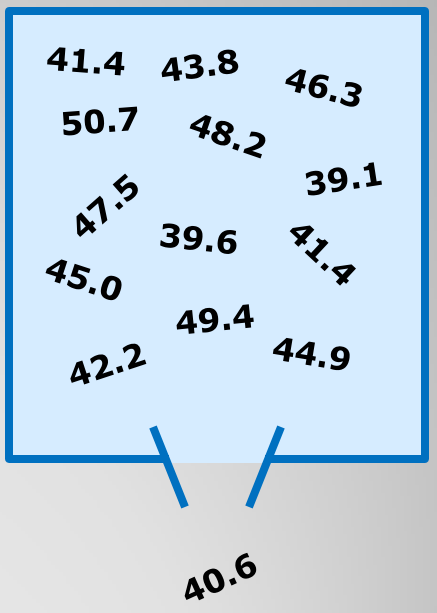
A Statistical Perspective

Climate is what you expect, weather is what you get.

- A simplified definition with a foundation in statistical probability, where *expectation* is associated with *average*.

- A more complete statistical definition would address aspects of the *variability* of possible weather that could be experienced.

Average = 44.3



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Weather, Climate, and Prediction

If we can't forecast the weather more than a few days ahead, how can we possibly predict what the climate will be decades into the future?

Credit: Dave Herholz

- What affects the probability of hitting a homerun in today's game?
- What affects the probability of hitting at least 40 homeruns over the entire season?

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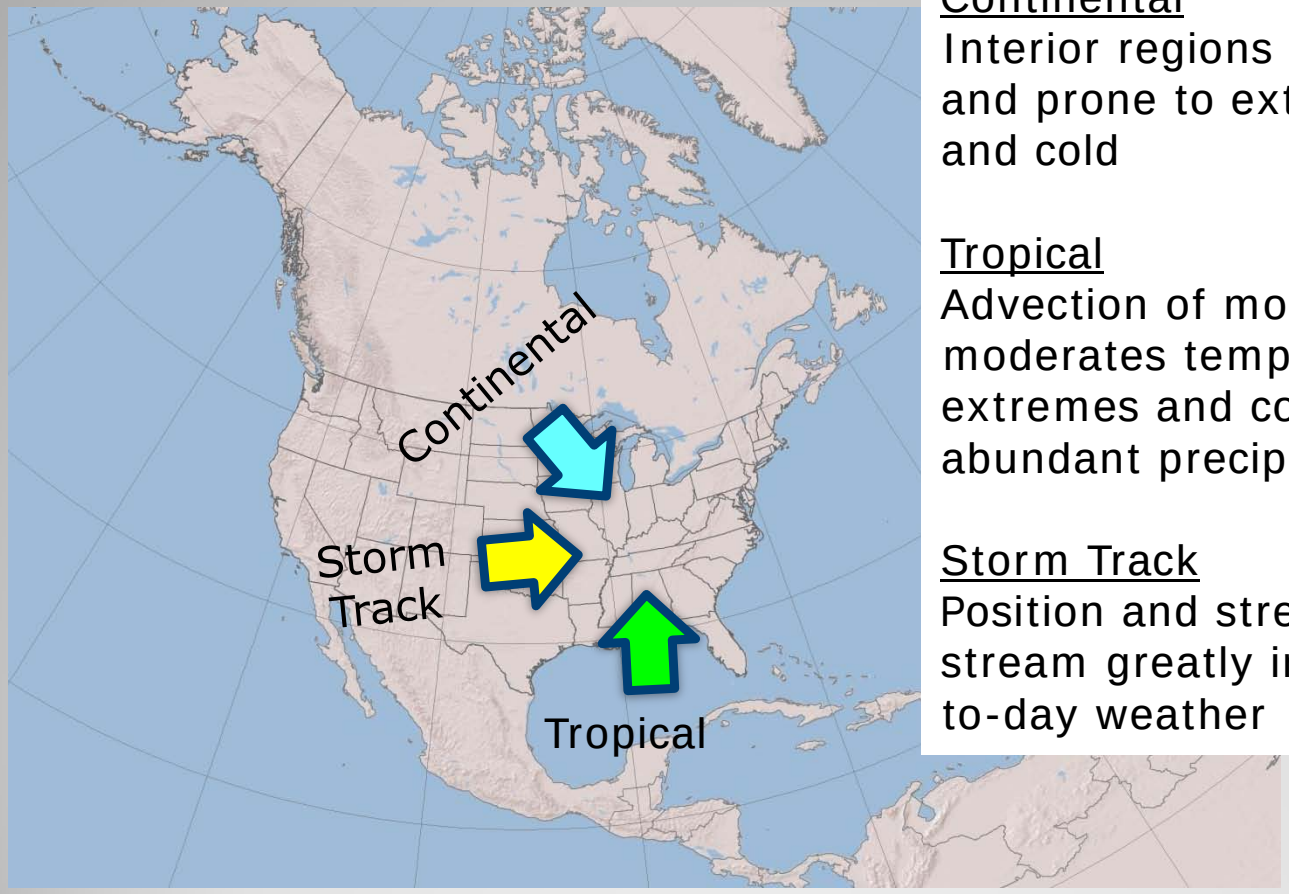
Key Climate Influences



<u>Continental</u>
Interior regions are often dry and prone to extremes of heat and cold

<u>Tropical</u>
Advection of moist tropical air moderates temperature extremes and contributes to abundant precipitation

<u>Storm Track</u>
Position and strength of the jet stream greatly influences day-to-day weather

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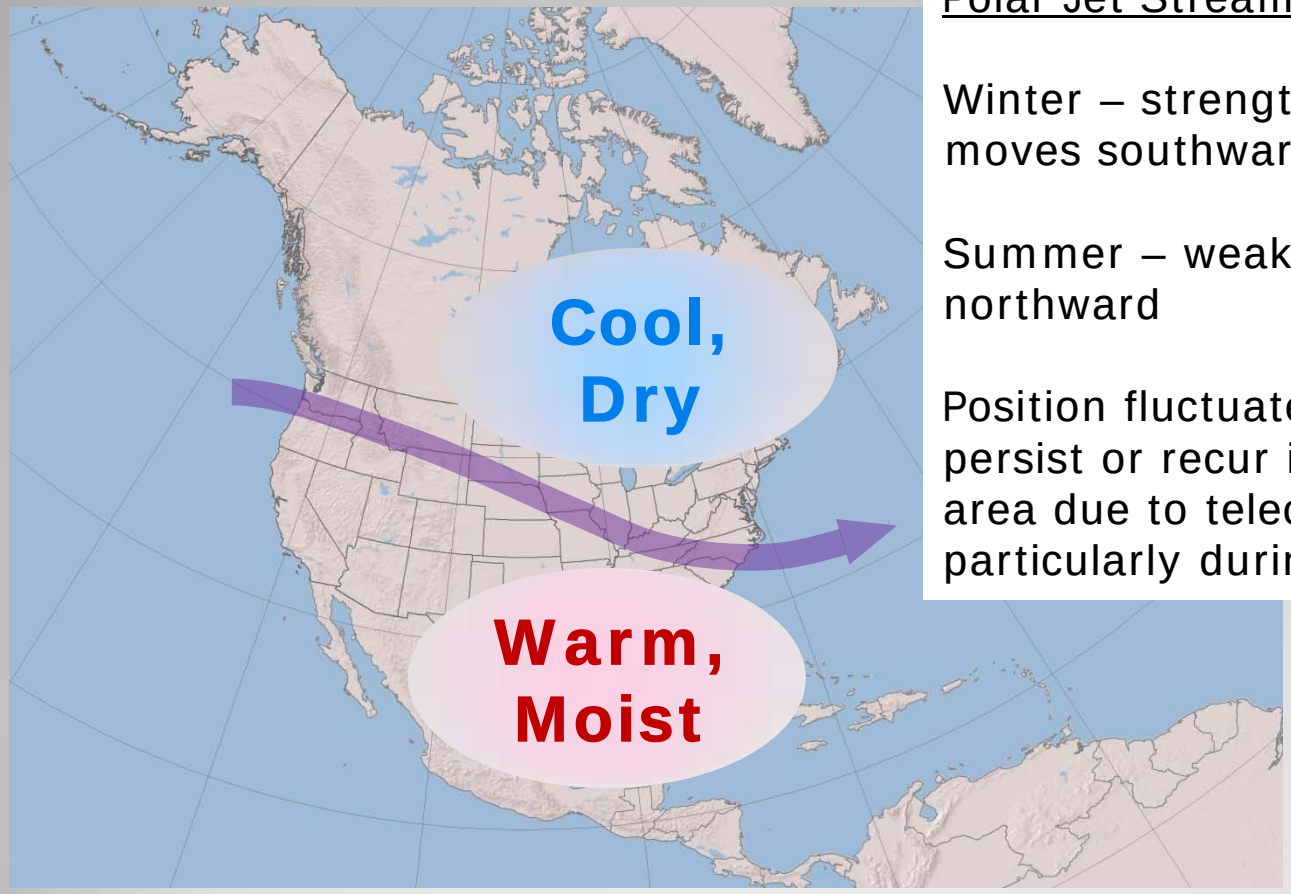
Polar Jet Stream



Polar Jet Stream

Winter – strengthens and moves southward

Summer – weakens and moves northward

Position fluctuates but can persist or recur in a favored area due to teleconnections, particularly during winter

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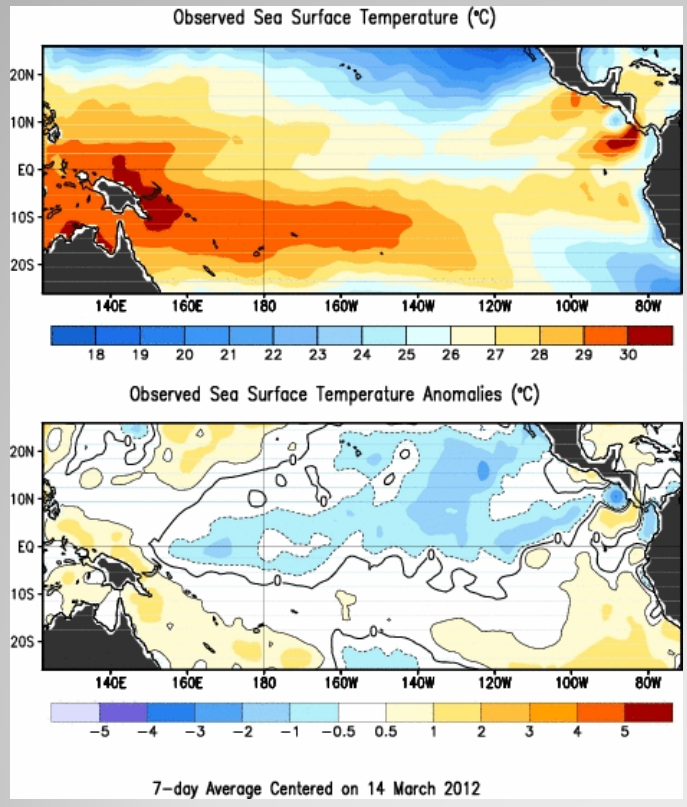
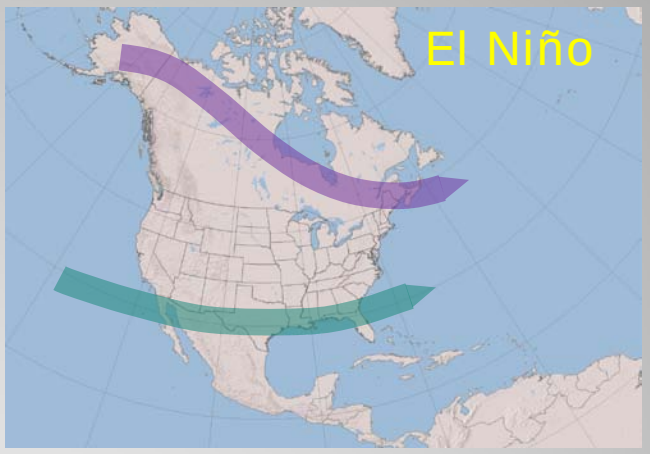
Generalized ENSO Circulation

Current Central Pacific Ocean Temperature



Source: CPC/NCEP/NOAA



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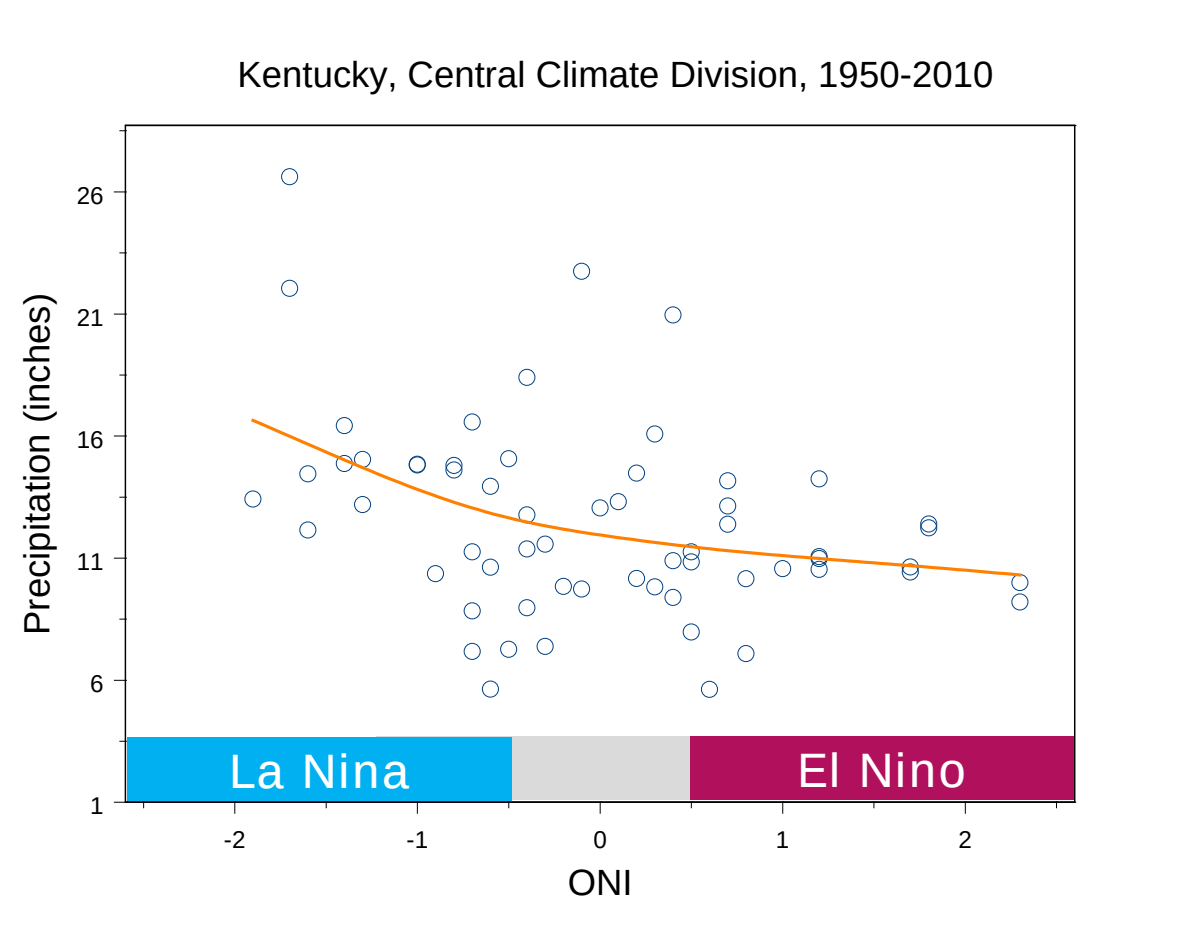
ENSO Impact on Winter Precipitation



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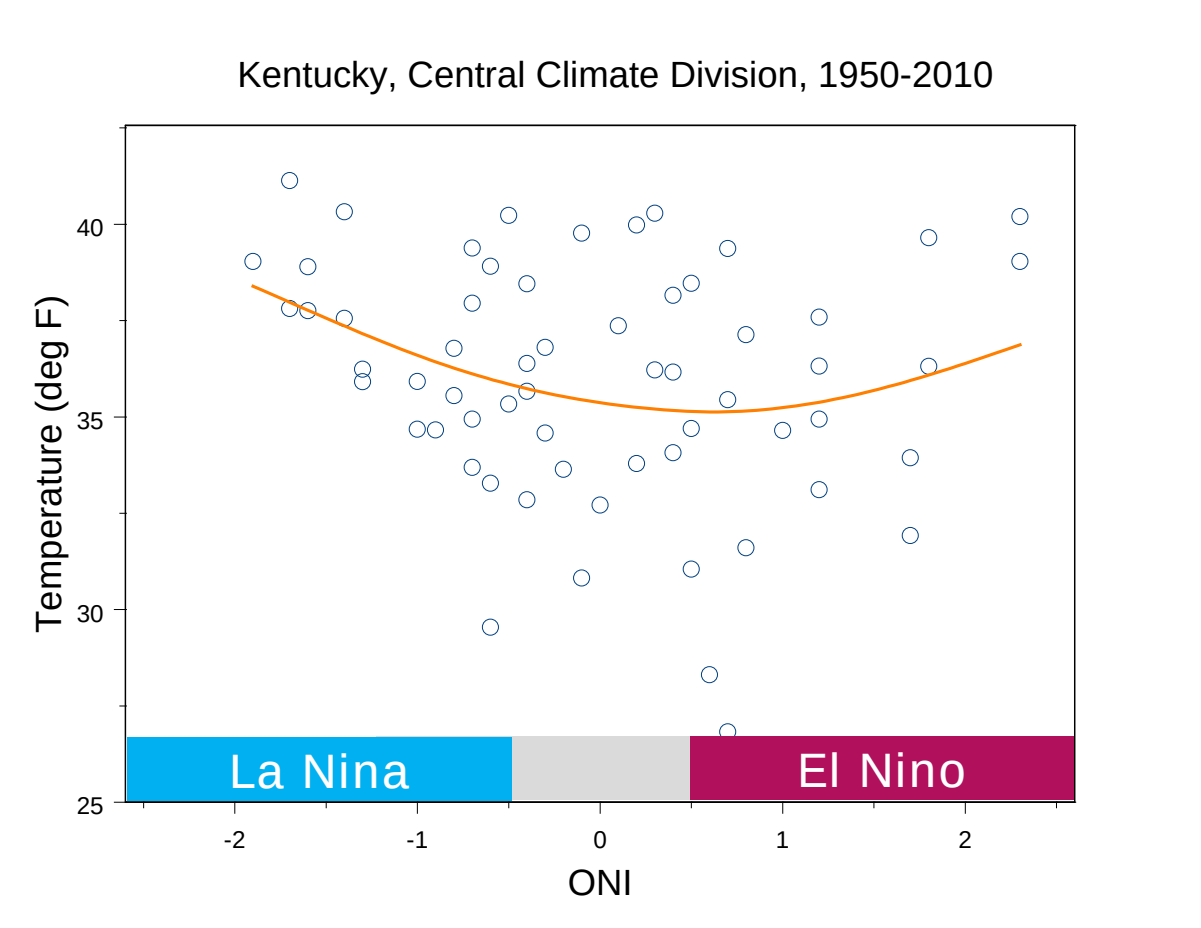
ENSO Impact on Winter Temperature



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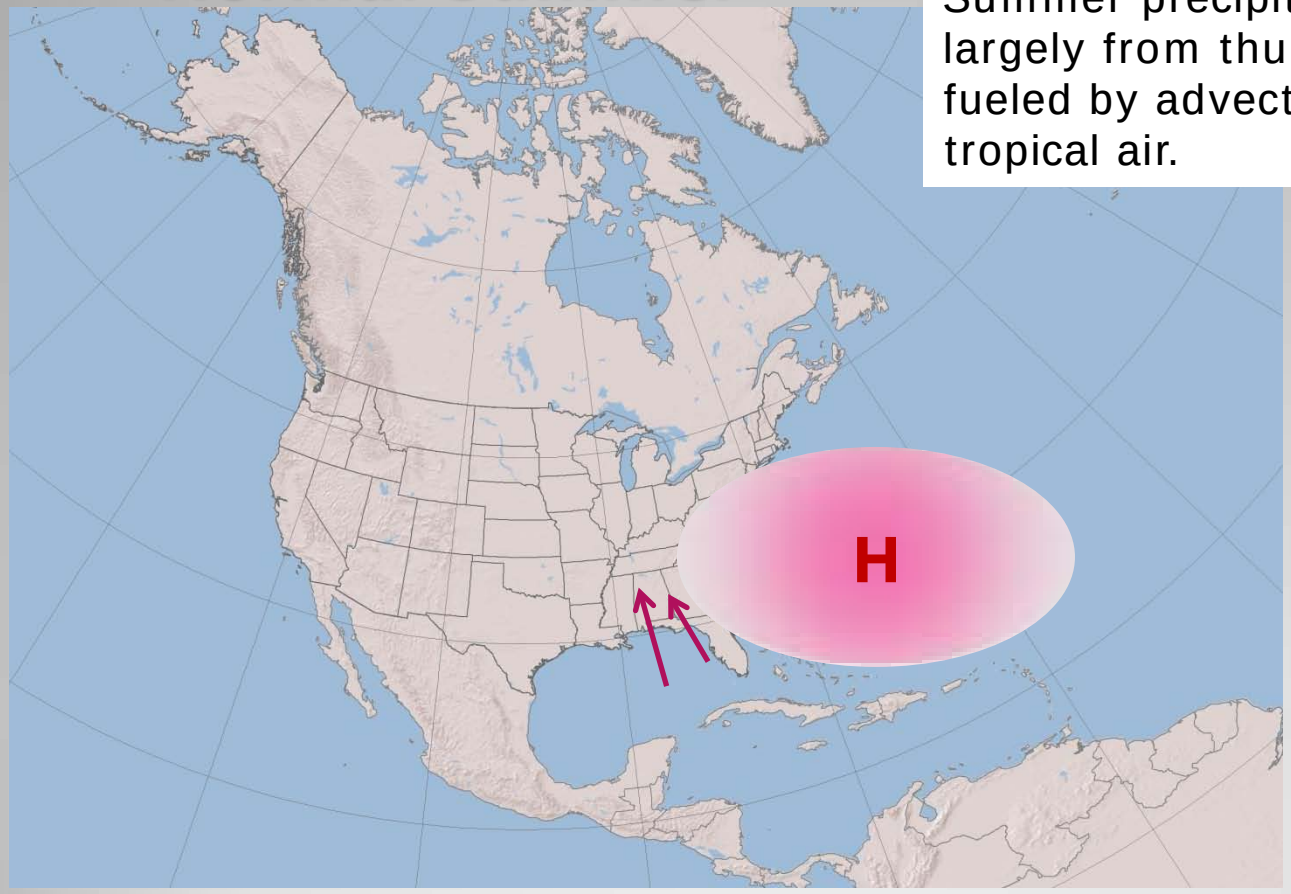
Bermuda High

Normal Summer



Summer precipitation results largely from thunderstorms fueled by advection of moist tropical air.

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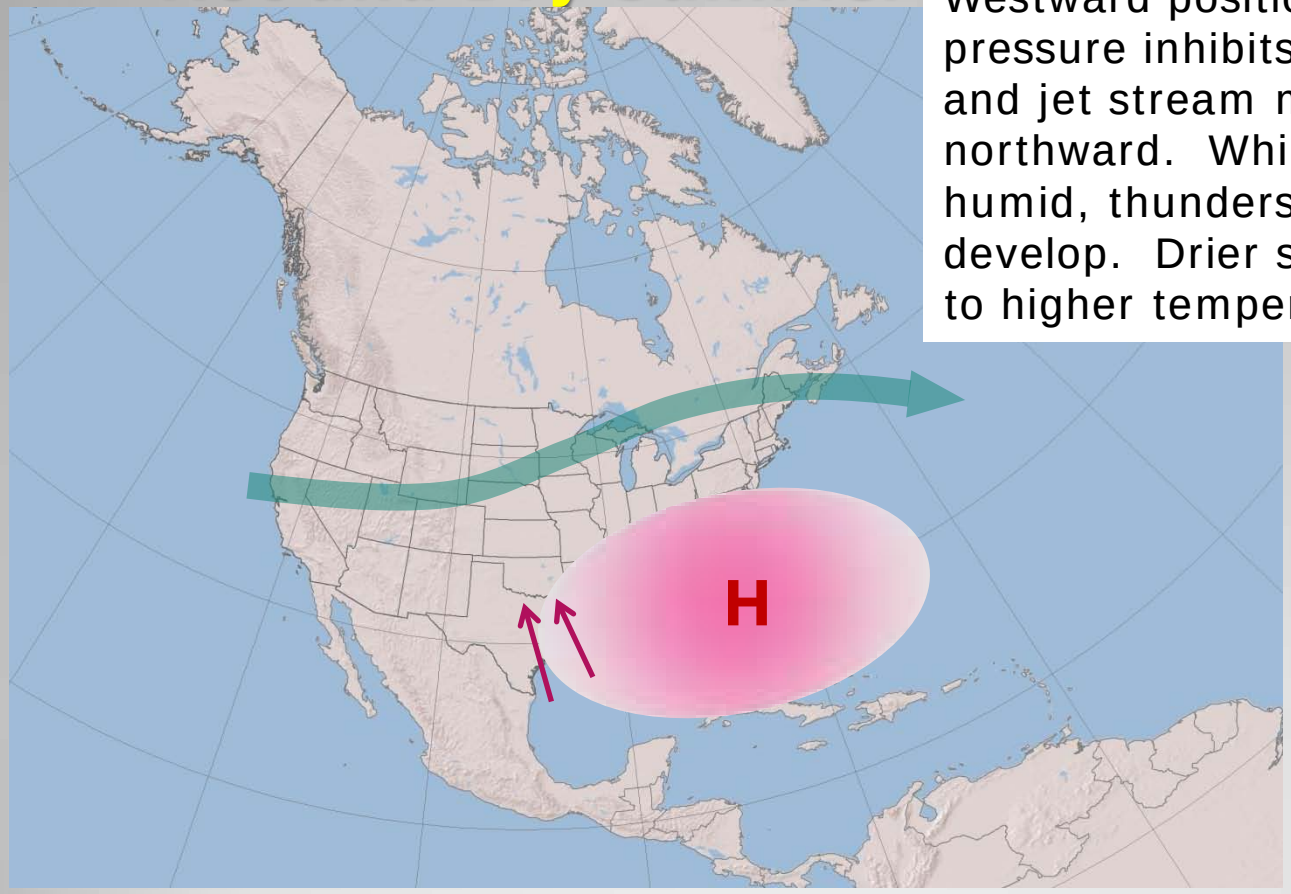
Bermuda High

Hot and Dry Summer



Westward positioning of high pressure inhibits convection, and jet stream migrates northward. While the air is humid, thunderstorms do not develop. Drier soil contributes to higher temperatures.

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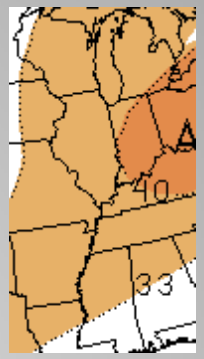
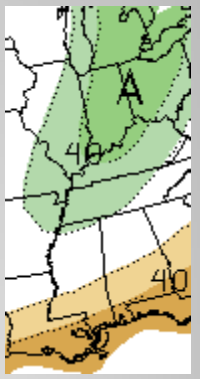
Climate Outlooks

- Climate Prediction Center (CPC) monthly and seasonal outlooks
- Outlooks based on signals provided by trends and teleconnections
- Factors Affecting Confidence
  - Signal strength
  - Signal predictability





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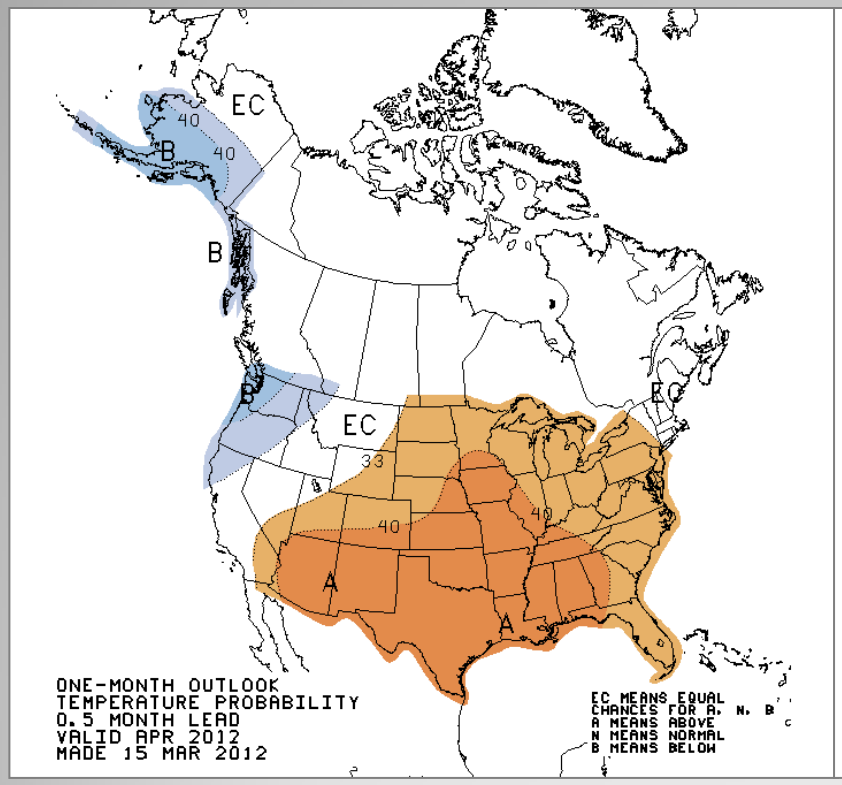
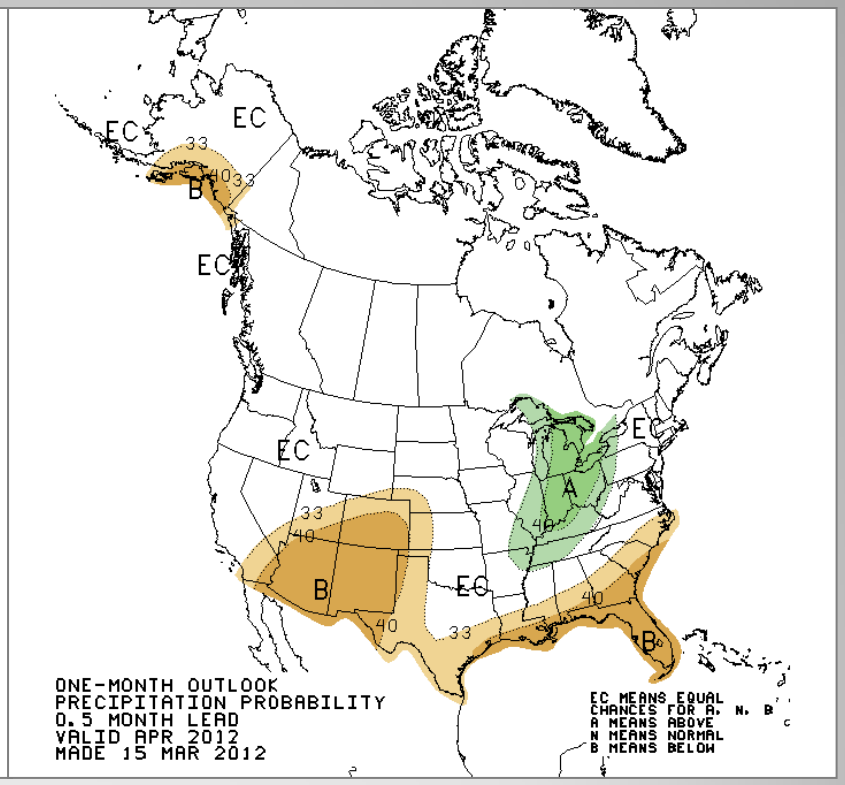
CPC Monthly Outlook



Temperature



Precipitation

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Natural Hazards

- Heat Waves
- Cold Waves
- Drought
- Ice and Snow
- Damaging Wind
- Lightning
- Hail
- Tornadoes
- Floods and Flash Floods

Historical extremes provide analogs that can help us to prepare for the future.

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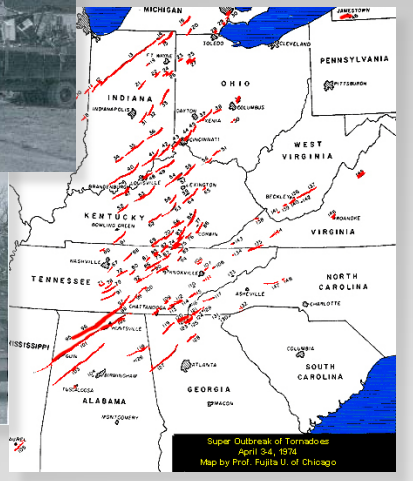
Tornado Outbreak 1974



Photos from NWS Archive

- At least 26 tornadoes struck 39 counties on April 3rd
- 77 people killed and 1,377 injured
- Brandenburg destroyed, 28 dead
- Pulaski County hit by 3 tornadoes

Hailstorm 1998

Impact in Warren County

- 11,000 homes damaged
- 10,000 automobiles damaged
- 16 airplanes damaged or destroyed

Photos BG Daily News

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River Floods

Photo from Courier Journal

The Great Flood of January 1937

- Precipitation averaged 15.77” statewide for the month
- Over 22” for in some areas
- More than 50% of Louisville and 95% of Paducah flooded

Communities in the Kentucky, Cumberland, Big Sandy, and Licking River basins have been devastated by flooding on many occasions, including 1927, 1937, 1957, 1977, and 1997.

http://hazardkentucky.com/flood.htm

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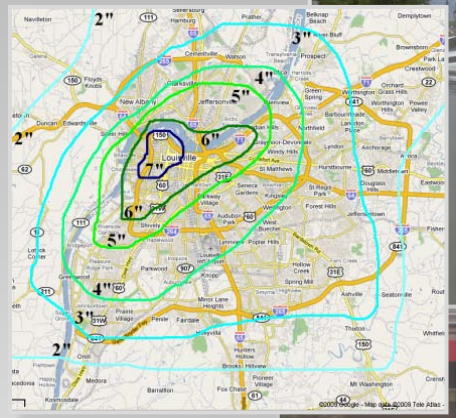
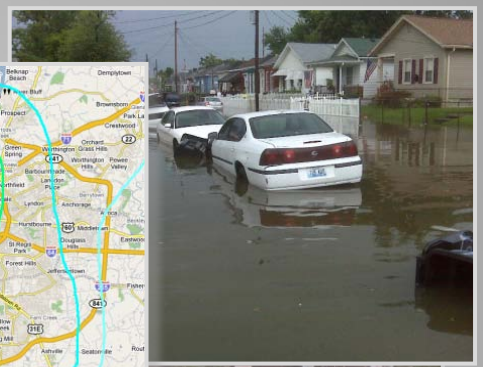
Flash Floods

Frozen Creek
July 4, 1939

- Precipitation estimates over 12”
- Wall of water estimated up to 22’
- Without warning, 79 people died

Source: www.breathittcounty.com





Source: NWS, Louisville WFO

Louisville
August 4, 2009

- Up to 6” within 3 hours
- Extensive property damage
- No fatalities, no injuries

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Drought

Drought Years

2010 *2007* *2000*

1988 *1963*

1953-54 *1941* *1936*

1930 *1914*

Impacts

- Increased fire danger
- Decreased air quality
- Low water levels in navigation channels
- Soil compaction
- Often accompanied by heat waves

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Winter Storms

The Courier-Journal

AT A STANDSTILL

THE FORECAST

TODAY
FLURRIES;
LOW TEMP:
-15°

TOMORROW
DRY;
LOW TEMP:
0-5

FRIDAY
DRY;
LOW TEMP:
Mid-teens

SATURDAY
DRY;
LOW TEMP:
15-20°

SUNDAY
DRY;
LOW TEMP:
30°

F.Y.I

GARBAGE: No city pickup today. Normal service expected tomorrow, continuing through Saturday.

TARC: Will operate shortened versions of at least 9 of 52 routes.

Routes are No. 4, Fourth Street; No. 33, Broadway; No. 17, Bardstown Road; No. 6, Sixth Street; No. 15, Market Street; No. 29, Gaslam Parkway; No. 18, Preston Highway and 18th Street; No. 19, Muhammad Ali; and No. 21, Chestnut Street.

U.S. MAIL: Sporadic home delivery today; full home delivery expected tomorrow.

AIRPORT: Most flights resumed yesterday, but parking lot was snowed in. Officials hope to clear lots today and tomorrow.

INSIDE

ROADS: City expects to clear major arteries and feeder streets that have bus routes tomorrow; state hopes to have main roads and Interstates open in

By ANDREW WOLFE
Staff Writer

BITTER CLIPPER
bitter cold
of record
Kentucky
Southern
residents
and mostly
— to get
normal year

Temperatures this
ing in Louisville were
expected to hit 15 de
below zero — a recor
the date — breaking
minus-14 mark set in
(The all-time low was
below in 1884 and 19
As many as five da
Kentucky were blanke
the storm that dumped
record 15.0 inches of
on Louisville.
All schools and mo
nesses are closed. For
first time in memory
interstate highways ha
been ordered closed
but essential vehicles
those carrying food, m
clear and hauling fuel.
Hundreds of aband
cars and trucks still
the Interstates, and sta
police warn that mo
who venture out on the
roads without good re
will be cited.
Highways are still
with a sheet of compa
ice and snow — and
die this frigid, salting
roads is useless. Side
remain clogged with sn
and many residents are
ning low on food and
Ten thousand custo
in Jefferson County we
still without power yes
day, including Ted and
Steffen, who cuddled be
fire over a camp stove
their garage after temp
ures inside their home
Cherokee Park Humane
in all.
At Ballitt Central Hig
School in Shepherdsvil
500 stranded motorists
crammed the cafeteria,
and hallways, making
bologna sandwiches.
TARC offered free ri
— but on only nine of 52
routes.
Since then 100 volun
with four-wheel-drive ve
cles motored through
wire impassable streets,
delivering kidney patient
life-saving dialysis mach
and blood to hospitals.
Barbara Pawsley's only w
home from the Veterans
Affairs Medical Center w
in the back of a pickup tr
— in a plywood box built
a dog.
Only five people show
up for the 8 a.m. Mass at
Stephen Mary Catholic
Church — including the

Hazards

- Snow
- Ice
- Cold Waves

Winter Storm of 1994

- Up to 1” of ice was covered by 6” to 26” of snow
- Interstates highways closed for 5 days
- Communities isolated without power
- Record low temperature for Kentucky of -37° F was recorded at Shelbyville

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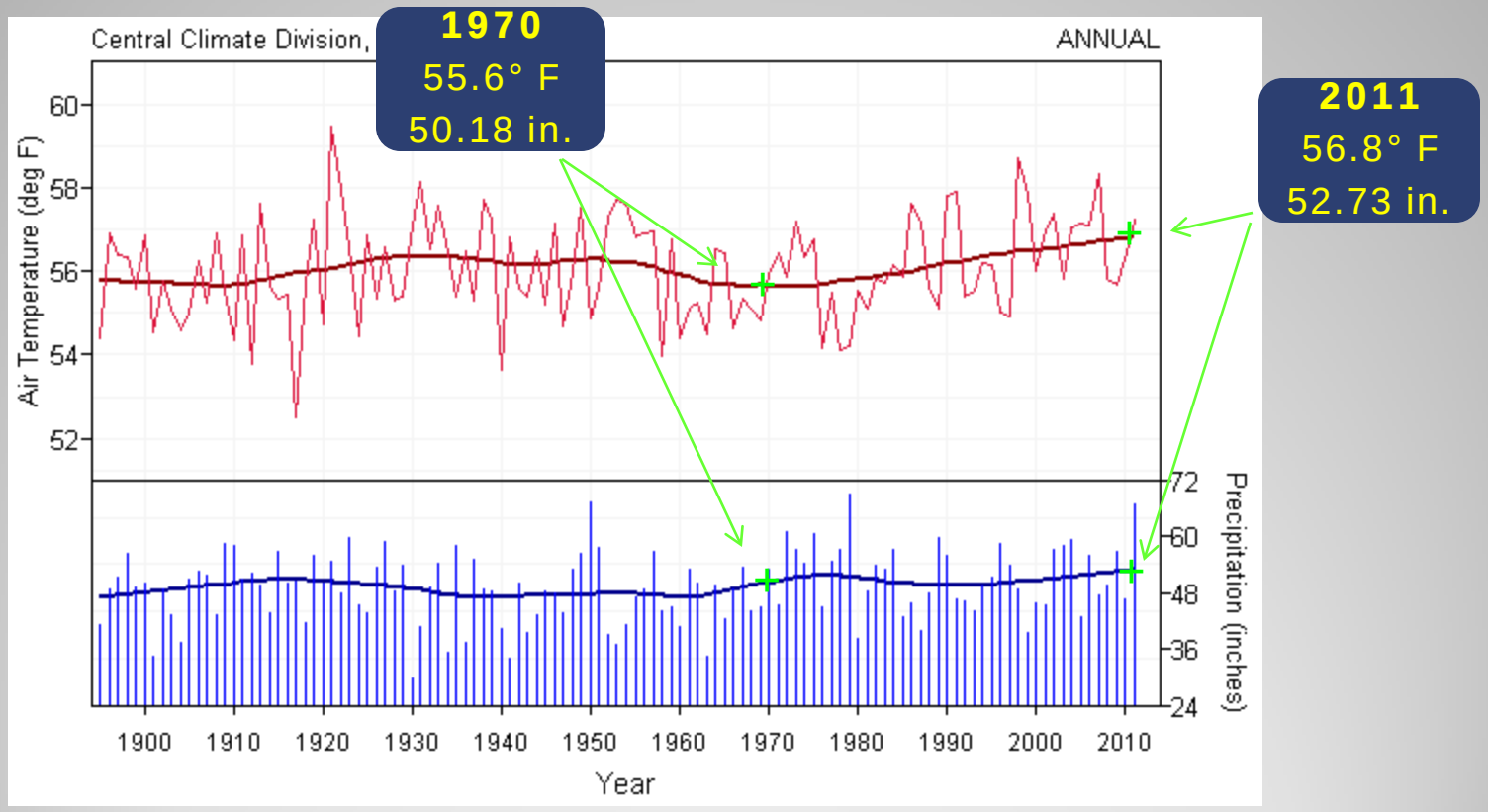
Climate Trends: Annual Averages

Central Climate Division



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Climate Trends – Annual Scale

Climatic Average Annual Temperature (°F)

Climate Division	1970	1980	1990	2000	2010
Western	56.7	57.0	57.3	57.7	58.2
Central	55.6	55.8	56.2	56.5	56.8
Bluegrass	54.1	54.3	54.8	55.2	55.5
Eastern	54.7	54.8	55.0	55.3	55.2

Climatic Average Annual Precipitation (in.)

Climate Division	1970	1980	1990	2000	2010
Western	48.99	50.14	48.77	49.51	50.98
Central	50.18	51.16	49.36	50.54	52.51
Bluegrass	45.42	45.63	45.22	46.54	47.15
Eastern	47.77	47.94	47.89	48.35	48.00

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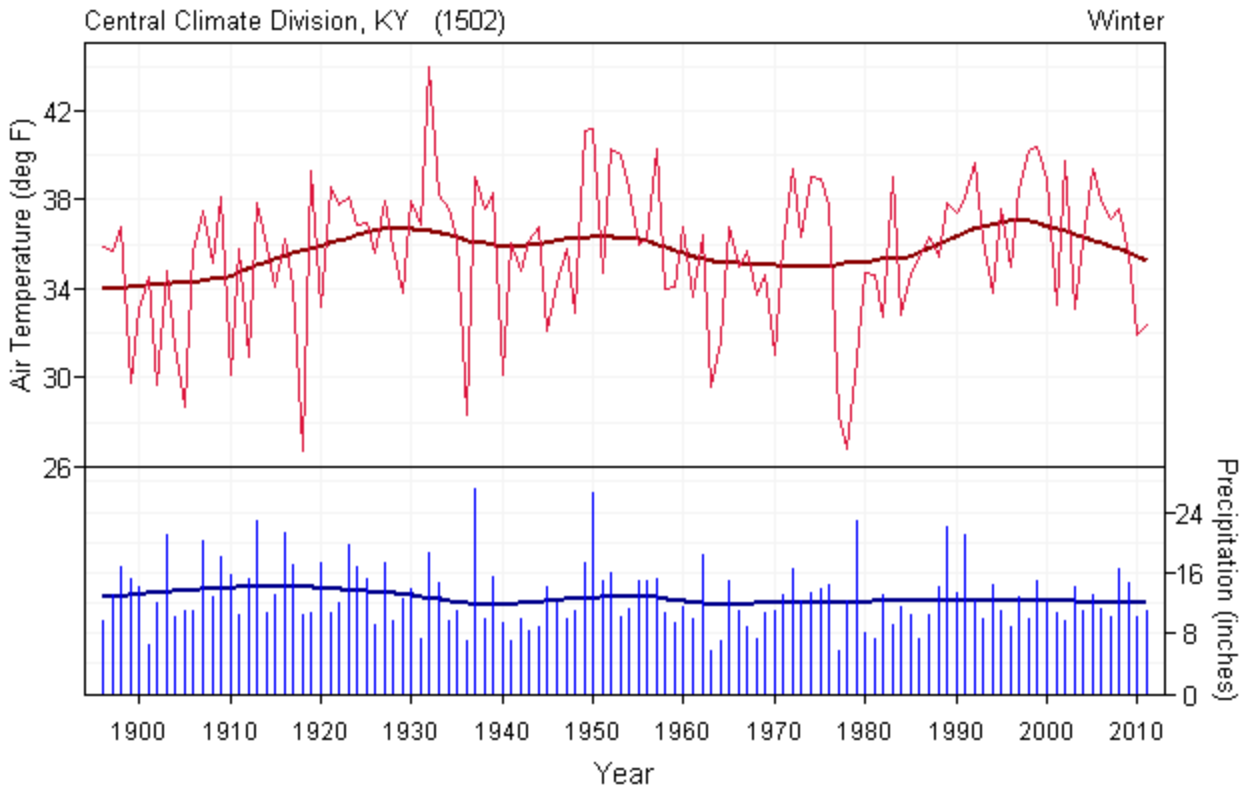
Climate Trends: Winter Averages

Central Climate Division



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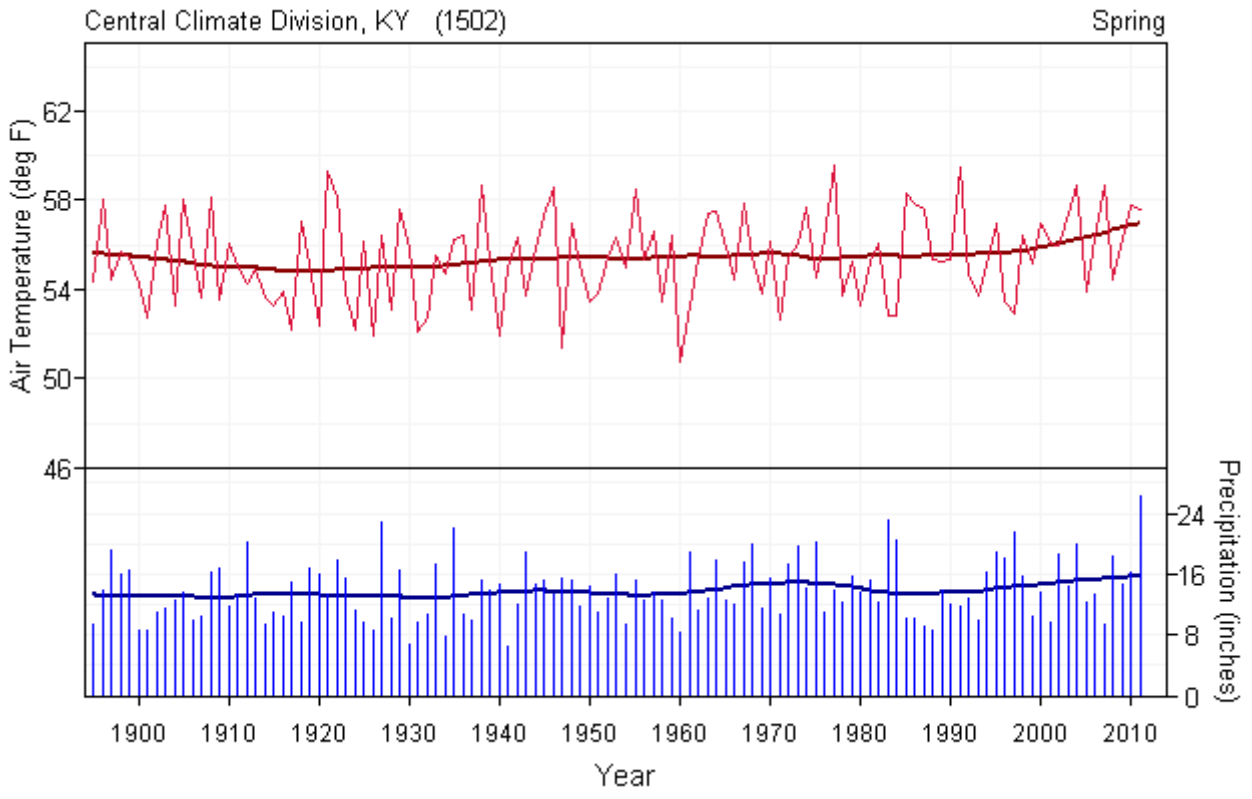
Climate Trends: Spring Averages

Central Climate Division



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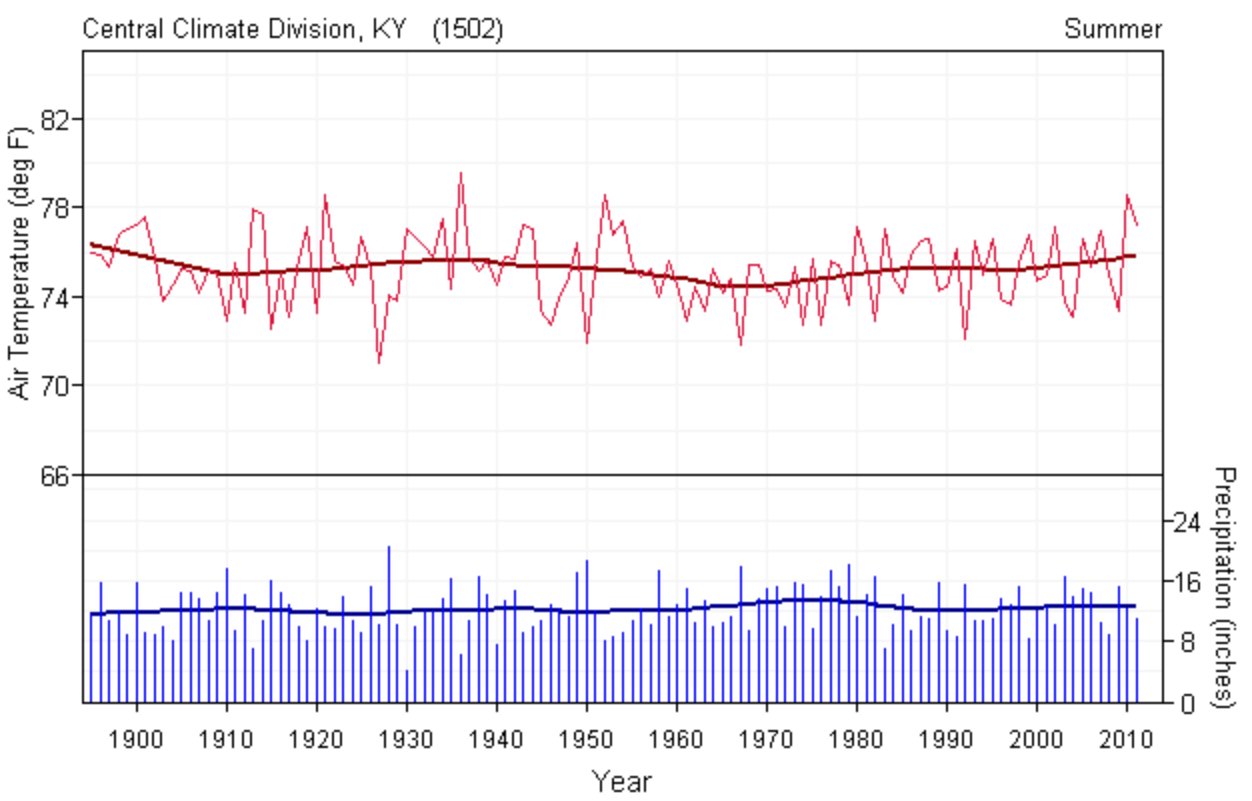
Climate Trends: Summer Averages

Central Climate Division



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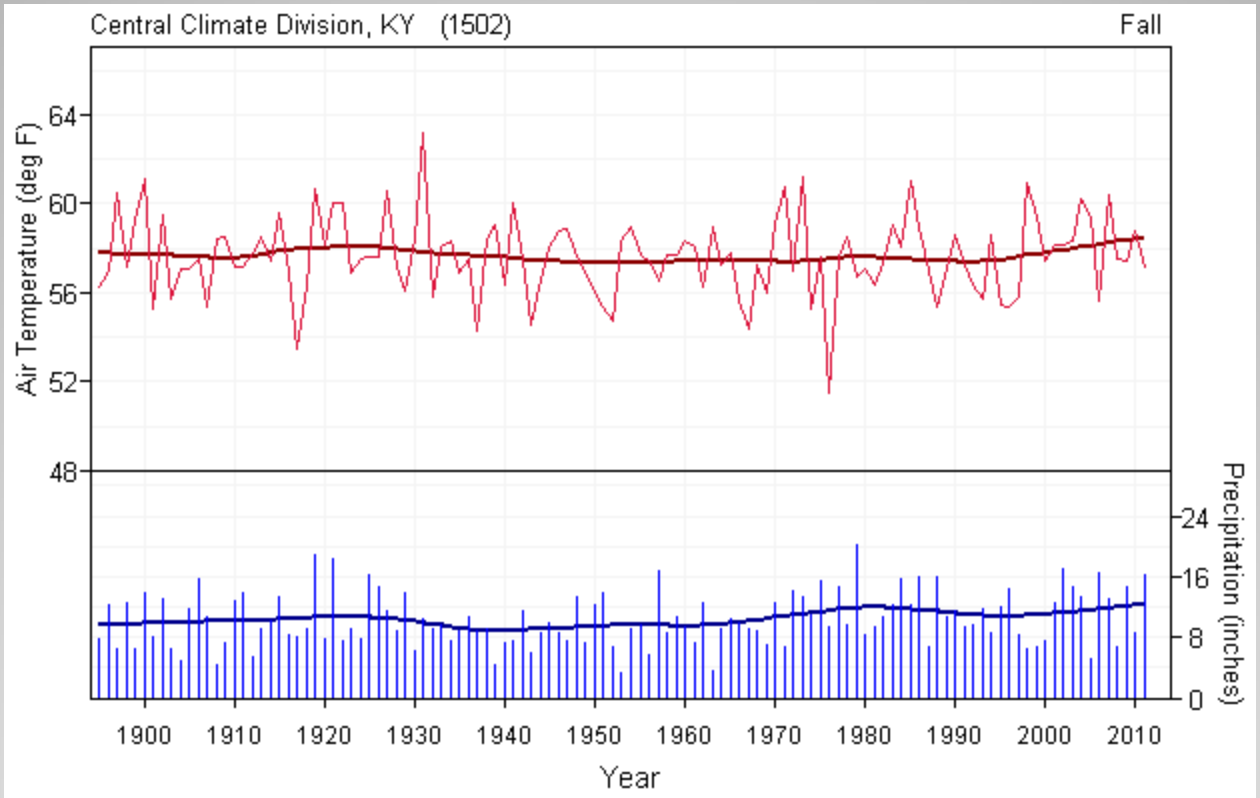
Climate Trends: Fall Averages

Western Climate Division



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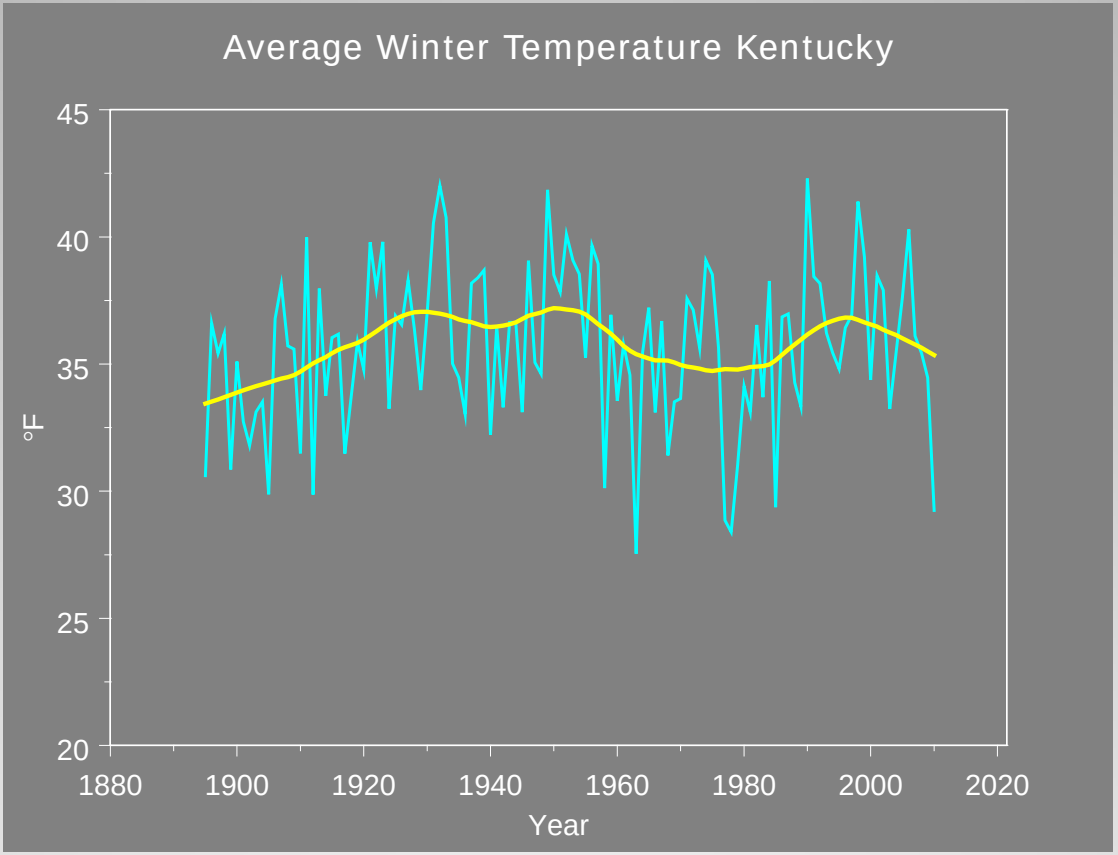
http://kyclimate.org/graphlets/climatechange.html

Kentucky Winter Temperature

Time Series with Smoothing Curve



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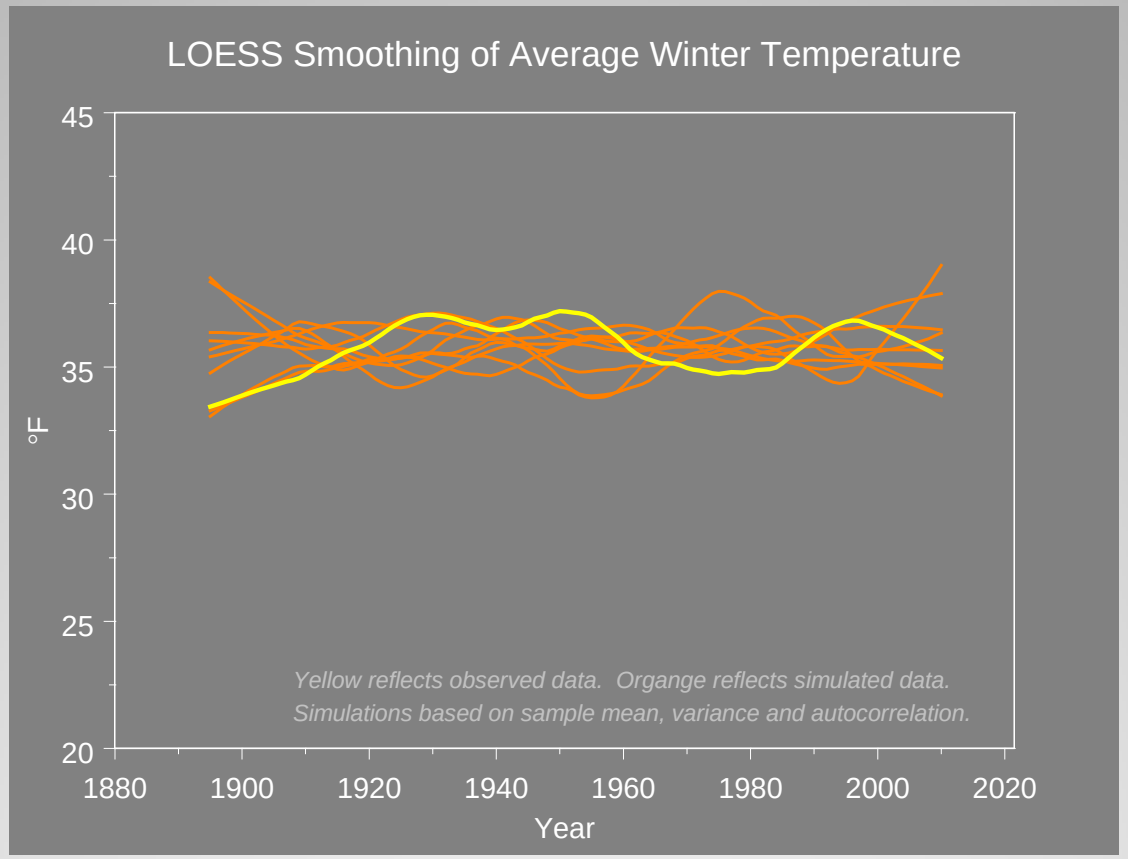
Variability or Change?

Winter



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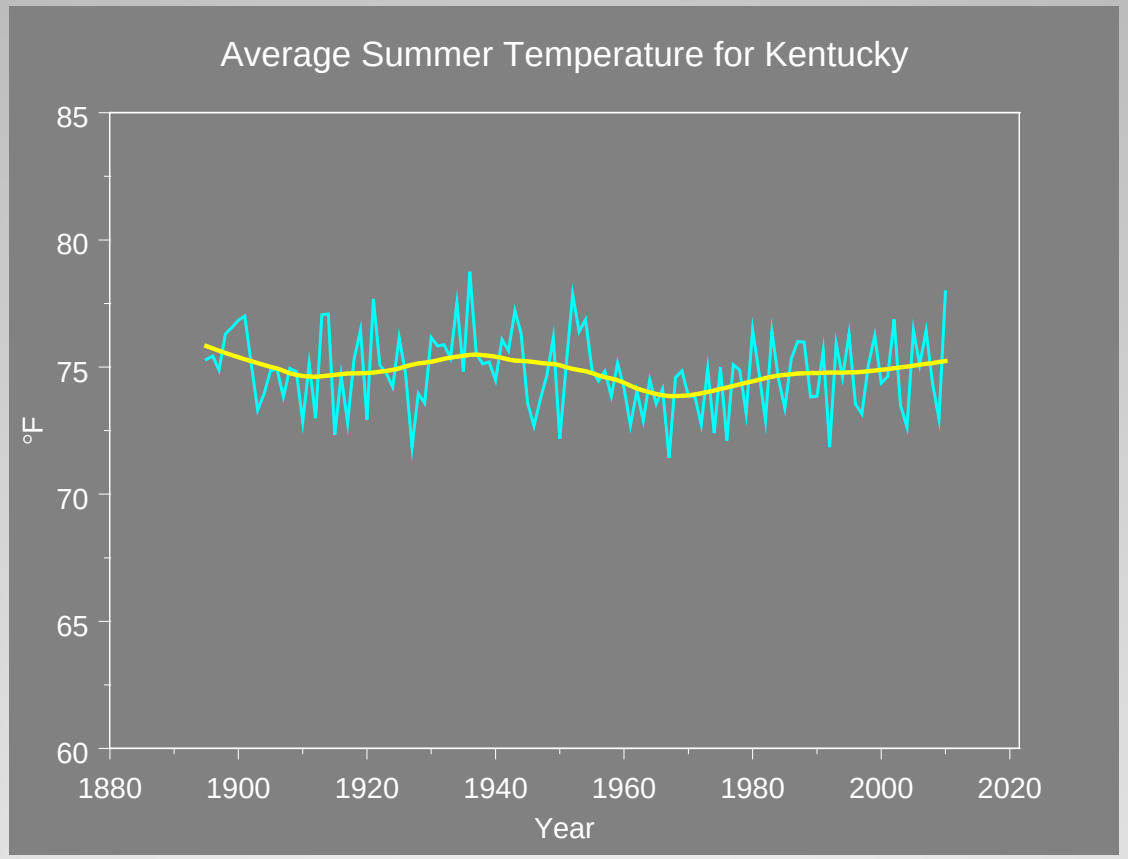
Kentucky Summer Temperature

Time Series with Smoothing Curve



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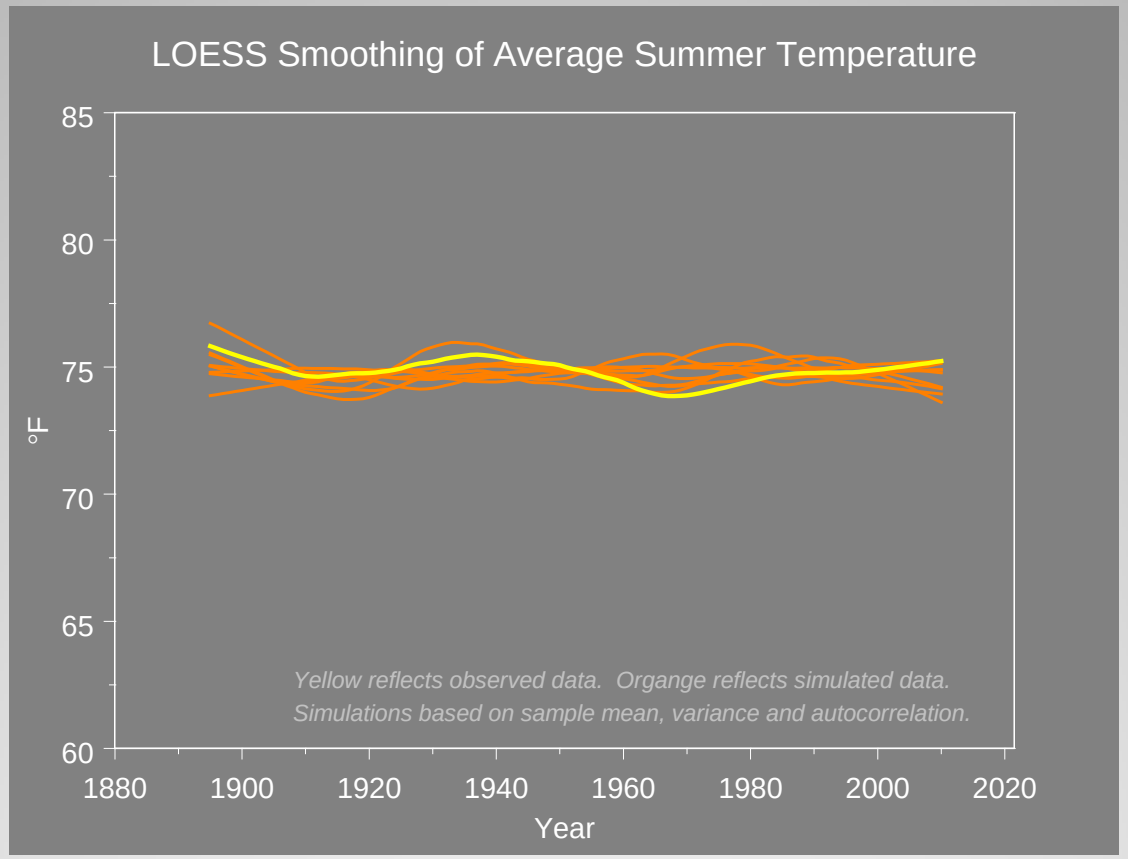
Variability of Change?

Summer



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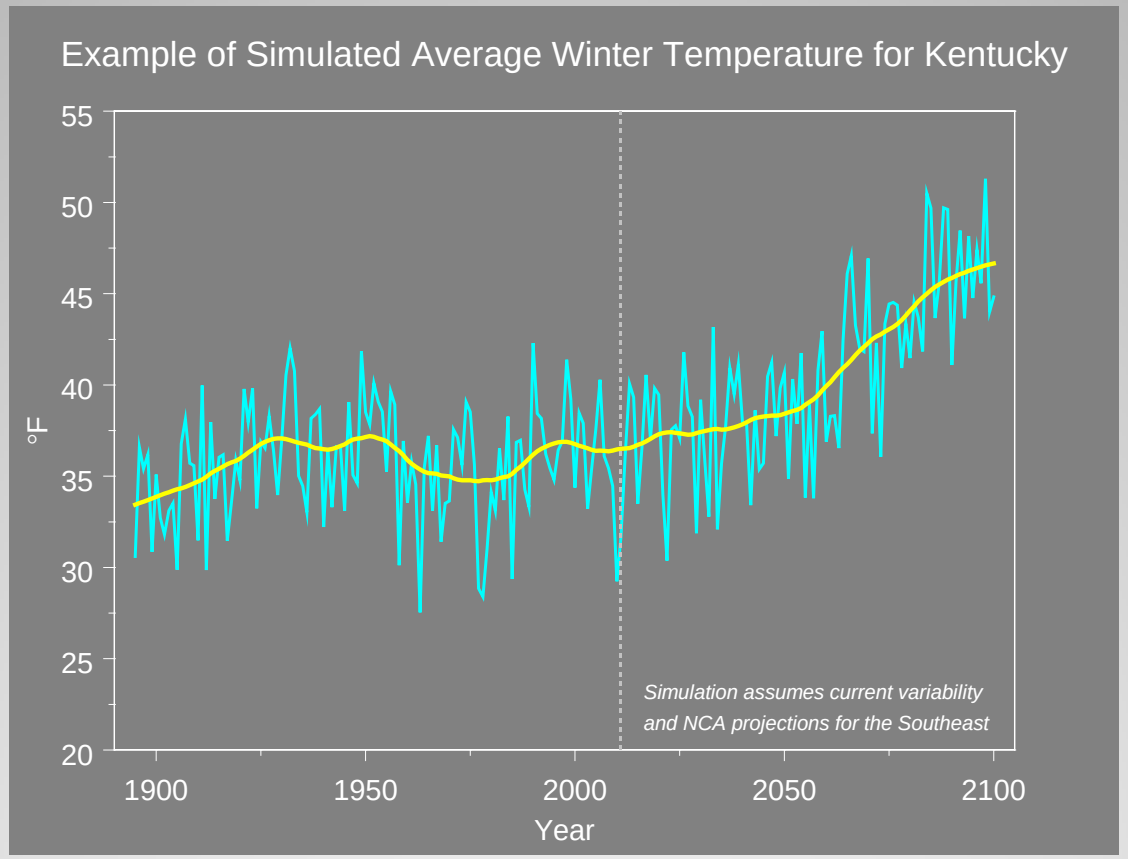
Example Future Scenario

Winter Temperature



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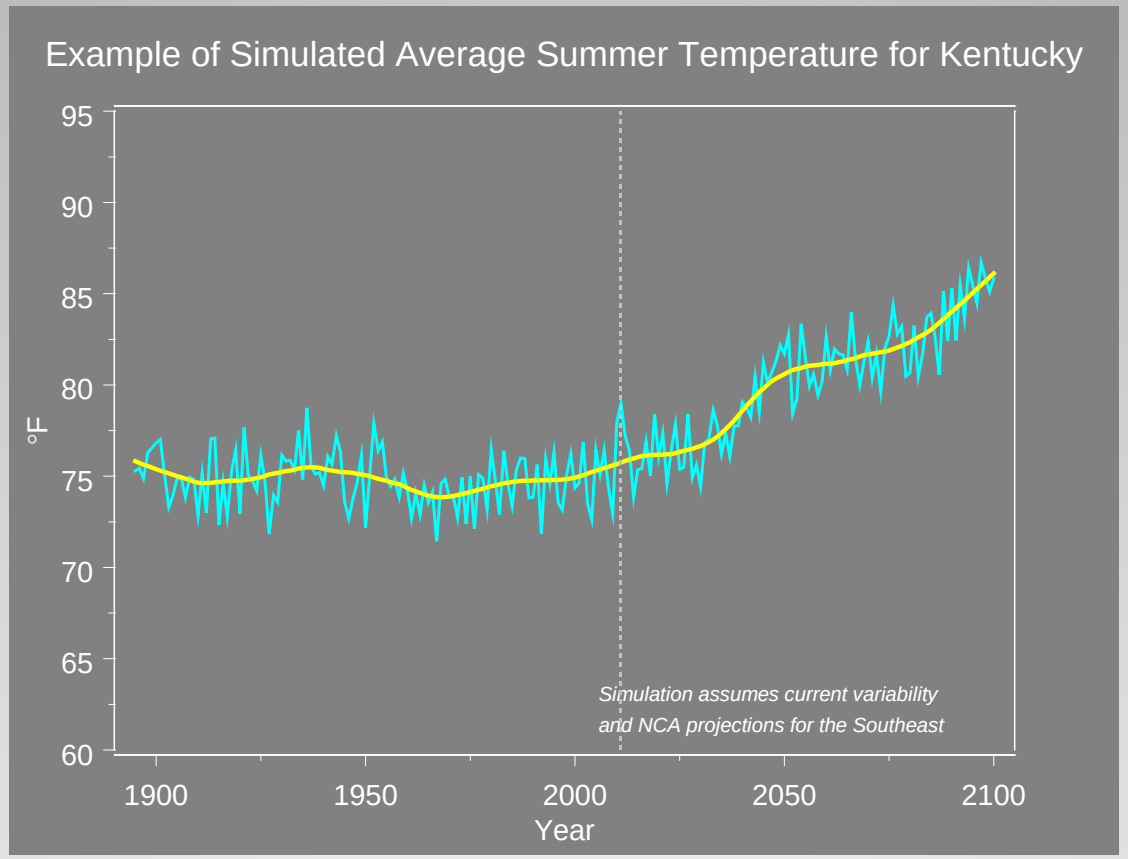
Example Future Scenario

Summer Temperature



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In a nutshell …

- Recent trends and historical context highlight variability with only minimal change
- Models project that Kentucky's future climate will lie beyond the range of recent historical variability

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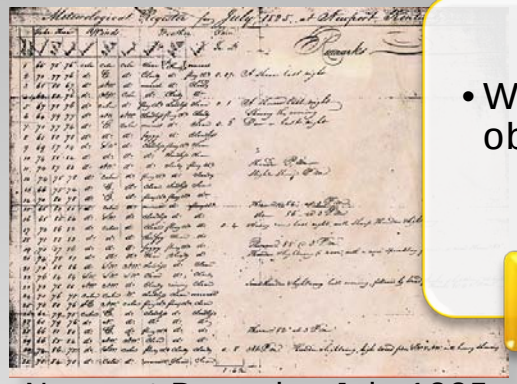
Kentucky's Climatological Record

- 1825 – U.S. Army
- 1861 – Smithsonian Institute
- 1874 – U.S. Army Signal Corps
- 1891 – U.S. Department of Agriculture
- 1940 – U.S. Department of Commerce
- 2007 – Kentucky Climate Center



Newport Barracks, July 1825

- Weather observations

Data

NWS COOP - Manual

NWS COOP - Automated

Kentucky Mesonet

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Selected Monitoring Sites

Graves County, KY

Campbell County, KY

Letcher County, KY

Clinton County, KY

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Vertically Integrated System

Test and calibrate instruments

Install and maintain instruments

Apply quality assurance procedures

Archive data and system metadata

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High-Quality Sites

High-Quality Data

Sites are selected to be representative of their surrounding areas

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Station Configuration

Sensor Package

- Air temperature
- Precipitation
- Solar radiation
- Relative humidity
- Wind speed and direction
- Soil moisture and temperature (*selected sites*)

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Meteorological Database

- Weather observations

Data

- Observations are taken every 5 minutes
- Each station collects over 105,000 observations each year
- Each station returns over 2,730,000 data values each year

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KYMN,ALBN,TBL_5min,"2010-05-01 11:15:00","2010-05-01 06:15:00 CDT","2010-05-01 05:15:00 CST",69.435,78.7,
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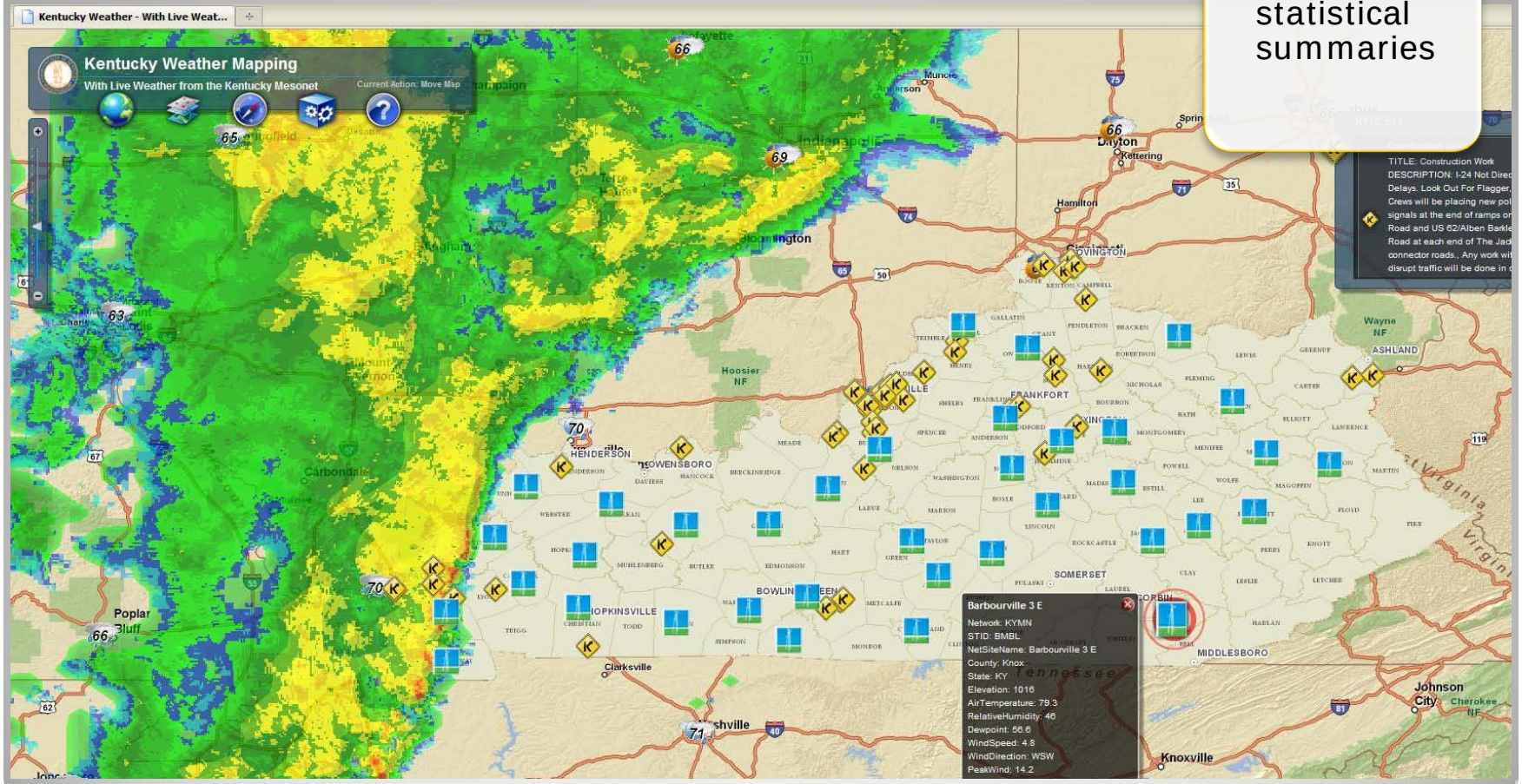
Kentucky Weather Mapping

Commonwealth Office of Technology, Division of Geographic Information

Information

- Graphical & statistical summaries



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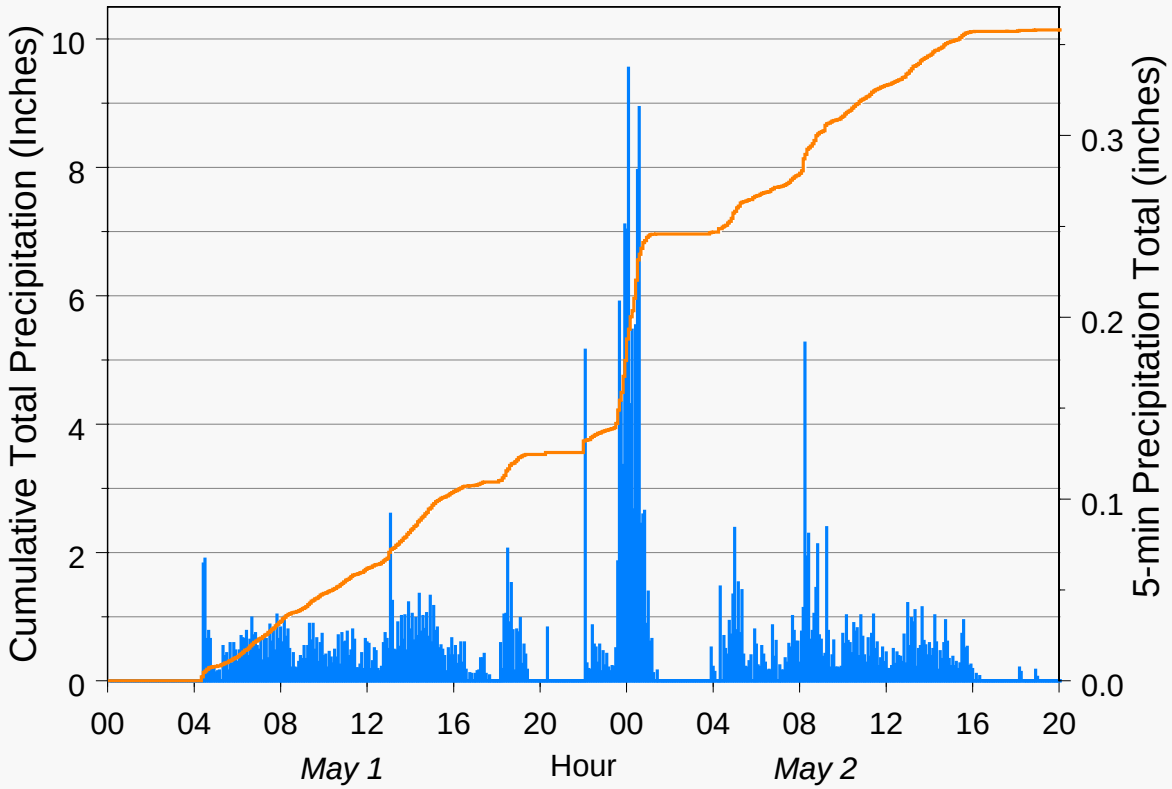
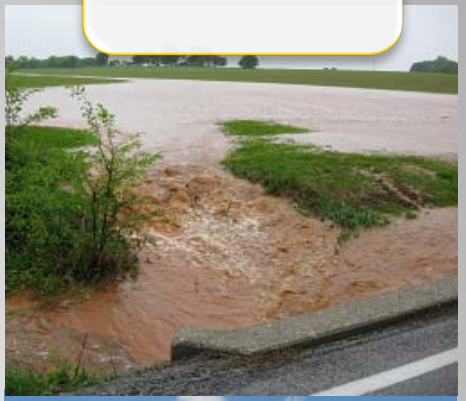
Precipitation Intensity

May 1-2, 2010



Information

- Graphical & statistical summaries



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Extreme Wind Gust

National Weather Service Text Prod...

```
1210 AM     TSTM WND DMG     MURRAY                 36.61N 88.32W
04/26/2011                   CALLOWAY          KY   EMERGENCY MNGR

            FROM HAZEL TO MURRAY WIDESPREAD WIND DAMAGE, HUNDREDS OF
            TREES UPROOTED, TREES DOWN ON HOUSES, POWER POLES AND
            LINES DOWN BLOCKING ROADWAYS. 8 FOOT SECTION OF WALL
            BLOWN OUT AT PELLA WINDOWS PLANT NORTH OF MURRAY. TWO
            BARNS BLOWN DOWN. COMMUNITY EOC BEING SET UP AT MURRAY
            STATE POLICE DEPARTMENT. HUNDREDS OF CALLS TO EOC FOR
            ASSISTANCE BUT NO INJURIES SO FAR.
```

KENTUCKY MESONET

Home About Instrumentation

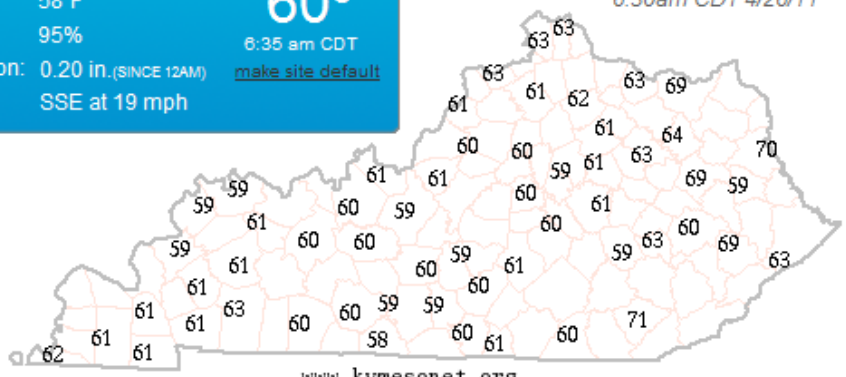
Warren County, KY
Bowling Green 5 S

Dewpoint: 58°F
Humidity: 95%
Precipitation: 0.20 in.(SINCE 12AM)
Wind: SSE at 19 mph

60°
6:35 am CDT
make site default

101 mph

Air Temp. (°F)
6:30am CDT 4/26/11



www.kymesonet.org

Temperature Precipitation Wind Moisture Other

(Mouse over the above text for more options)

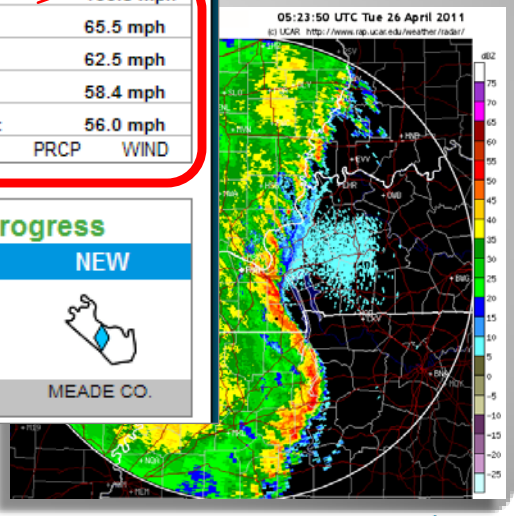
Highest Gusts
Last 24 Hours

Murray 1 W:	100.8 mph
Henderson 5 E:	65.5 mph
Marion 4 NE:	62.5 mph
Leitchfield 3 W:	58.4 mph
Hopkinsville 6 N:	56.0 mph

MAXT MINT PRCP WIND

Site Progress

NEW	NEW
BATH CO.	MEADE CO.



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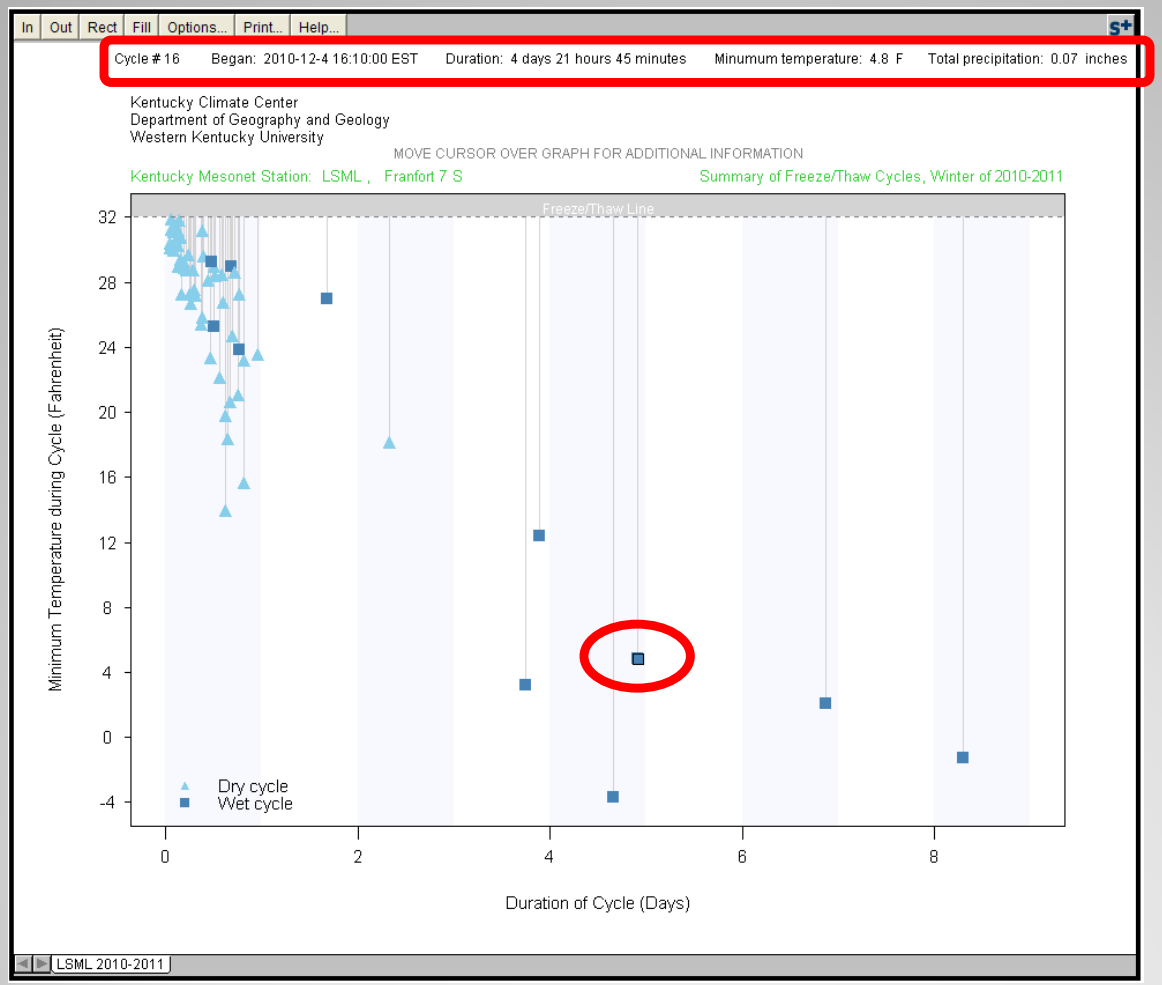
Freeze-Thaw Cycle Analysis



Information

- Graphical & statistical summaries

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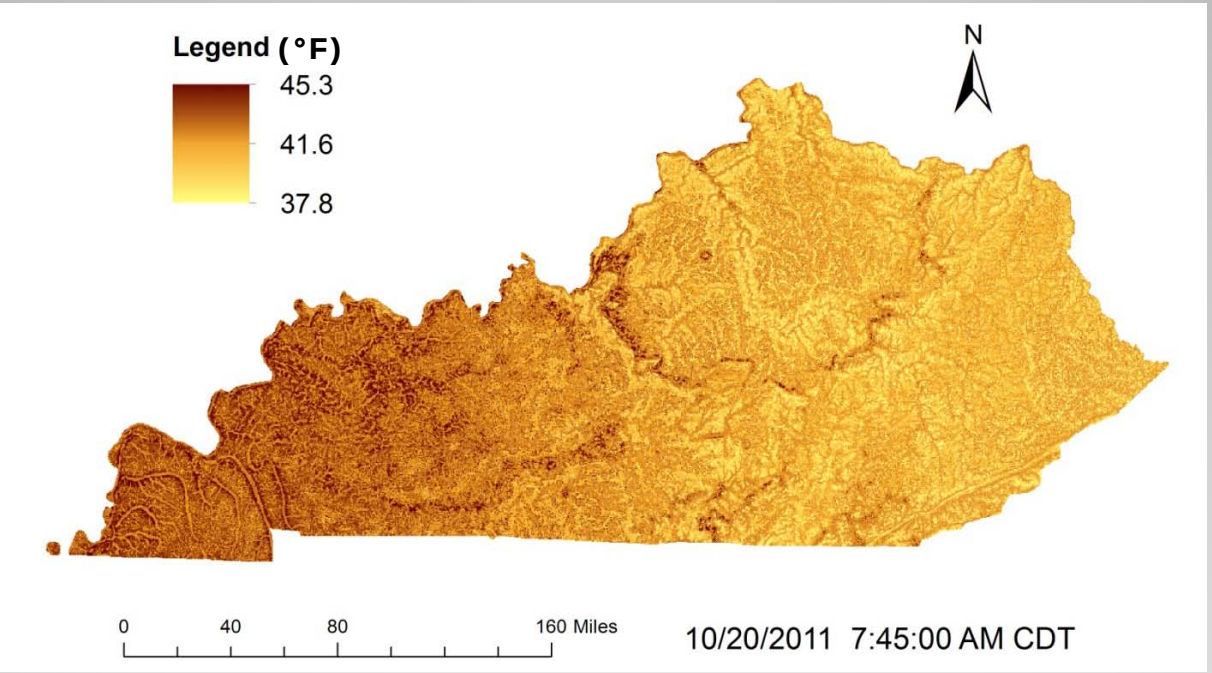
Experimental Interpolated Temperature Map



► *Model produces estimates for over 500,000 grid points*

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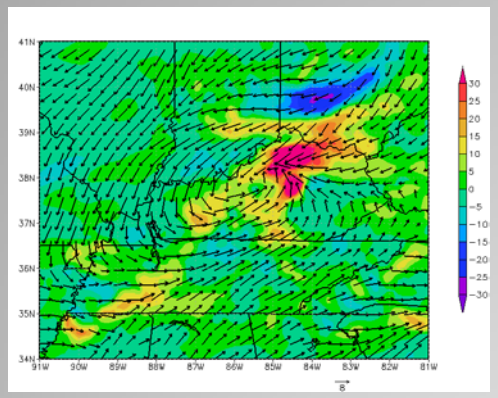
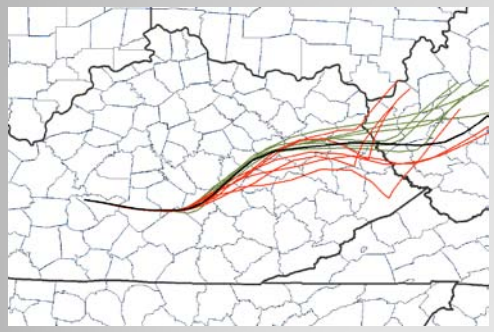
Weather Modeling and Forecasting





Data Assimilation

- Regional and global databases
- High-resolution Mesonet data

Model Output

- High-performance computing system
- Ensemble of forecast models

Local Forecast

- Adjustments based on local knowledge
- Verification and analysis

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The Issue of Climate in Perspective

- Kentucky's climate is a valuable resource, yet an ever present threat
- Annual variability and long-term change create uncertainty
- Managing uncertainty is vital for both operational and strategic decision making

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A Sense of Direction

Data — Are relevant data available to aid decision making?

Information — Can useful information be extracted from the data?

Knowledge — Does information lead to greater knowledge?

Decision — Does greater knowledge lead to better decisions?

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