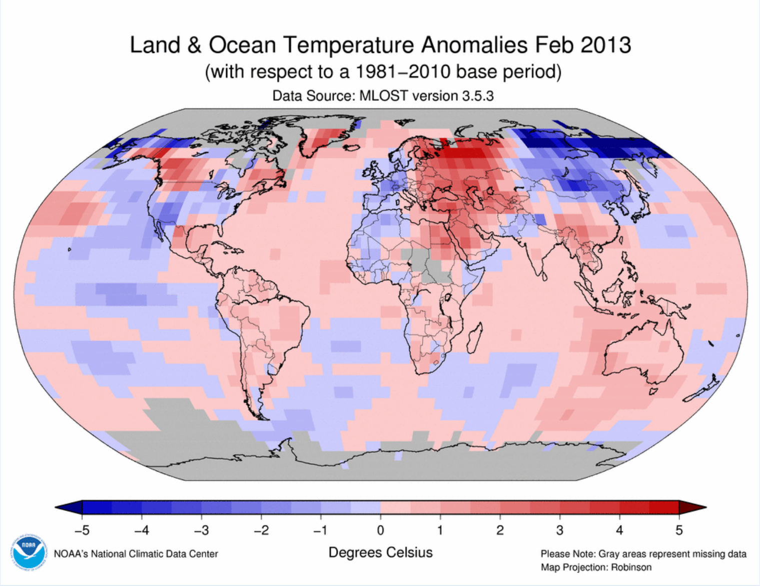
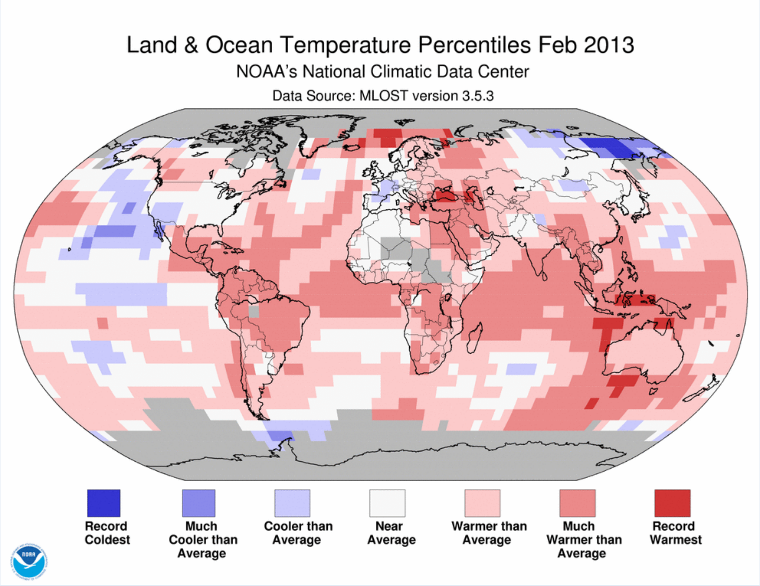
Why Climate Data Matters





Deke Arndt
NOAA's National Climatic Data Center

Presented at: Asheville Chapter of 350.org
September 28, 2012

The National Climatic Data Center's Climate Monitoring Branch

Mission: To monitor and assess the state of the climate

- CMB was established 1998 during record-breaking global temperatures
  - Interest in climate (and climate change) was high
- CMB provides regular updates of the State of the Climate

http://www.ncdc.noaa.gov/climate-monitoring

Preamble:
Do Weather and Climate Matter?

- Some perspectives from some sources

Colon, 1959

- *"On Tuesday, July 22nd, he departed for Jamaica … the sky, air and climate there were just the same as in other places; every afternoon there was a rain squall that lasted for about an hour. The admiral writes that he attributes this to the great forests of the land; he knew from experience that formerly this also occurred in the Canary, Madeira and Azore Islands, but since the removal of forests that once covered those islands they do not have so much mist and rain as before."*
- Biography of Christopher Columbus. Translated to English in 1959, 465 years after July 22nd, 1494

Homer, 900[ish] B.C.

- As for your own end … the gods will take you to the Elysian plain, which is at the ends of the world. There fair-haired Rhadamanthus reigns, and men lead an easier life than anywhere else in the world, for in Elysium there falls not rain, nor hail, nor snow, but Oceanus breathes ever with a West wind that sings softly from the sea, and gives fresh life to all men. This will happen to you because you have married Helen, and are Jove's son-in-law."

Also Long Ago

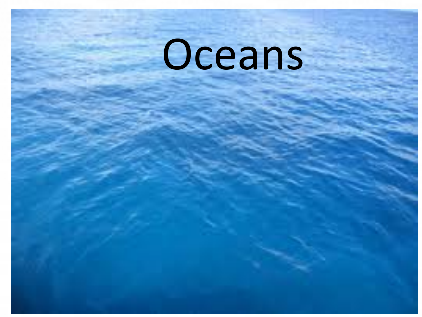
- … saying to the crowds, "When you see a cloud rising in the west, immediately you say, 'A shower is coming,' and so it turns out. And when *you see* a south wind blowing, you say, 'It will be a hot day,' and it turns out *that way*. – Luke 12:55
- "… and when it was morning, the east wind brought the locusts." – Exodus 10:13

A Few Notes Before We Start

- Weather is complex
- The intersection of weather and climate is quite complex
- The intersection of extreme weather and climate is stunningly complex
- **Science is Conservative**

Understanding One Piece of a Very Big Puzzle

It's such a complex, interconnected system of system.



Many, many scientists from many, many disciplines contribute to fitting the pieces together

Topics for Today

PART I: Current / Recent State of the Climate

PART II: The General Relationship between [Extreme] Weather and Climate

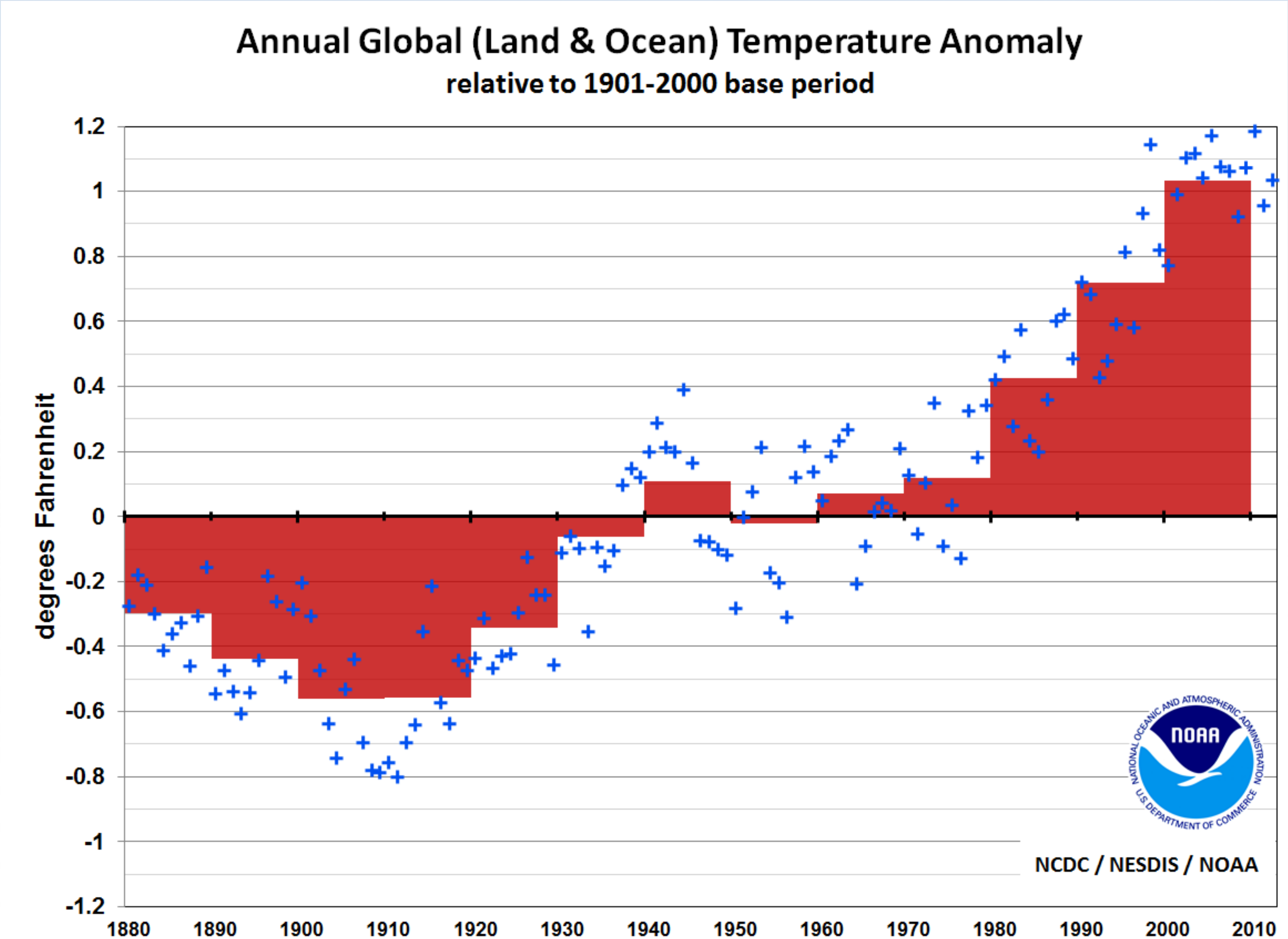
PART III: Observations and Expectations for Specific Hazards

Some Resources

- Most of this presentation comes from four sources:
  - BAMS State of the Climate
    - http://www.ncdc.noaa.gov/bams-state-of-the-climate/
  - National Climate Assessment Report
    - http://www.globalchange.gov/
  - Extreme Weather Paper
    - Kunkel et al., (2012). Monitoring and Understanding Trends in Extreme Storms: State of Knowledge, *Bulletin of the American Meteorological Society*
  - NCDC's Climate Monitoring Branch
    - http://www.ncdc.noaa.gov/climate-monitoring

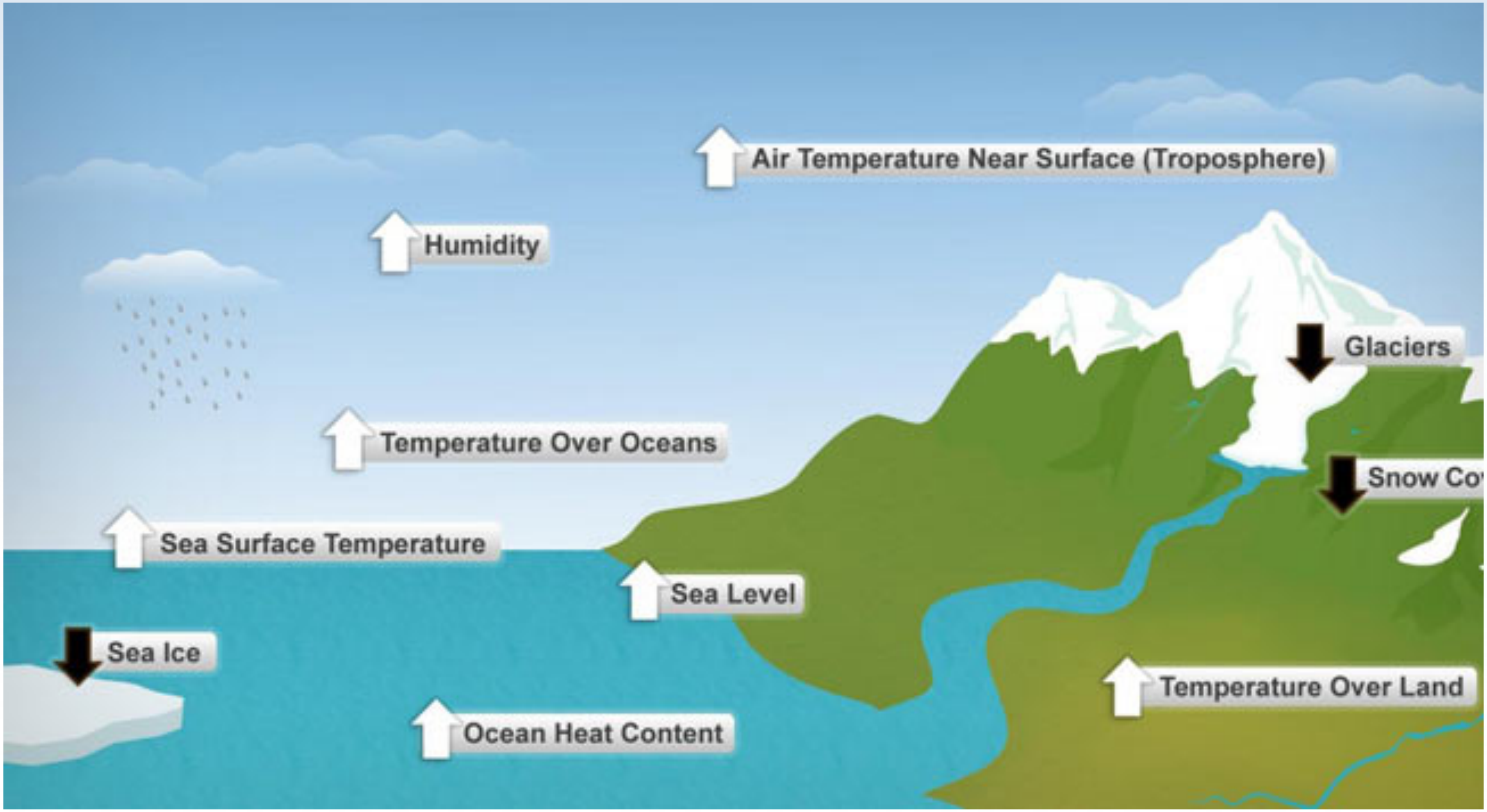
PART I:
CURRENT STATE OF THE CLIMATE

Global Temperature Decadal Average: 1880 - 2012

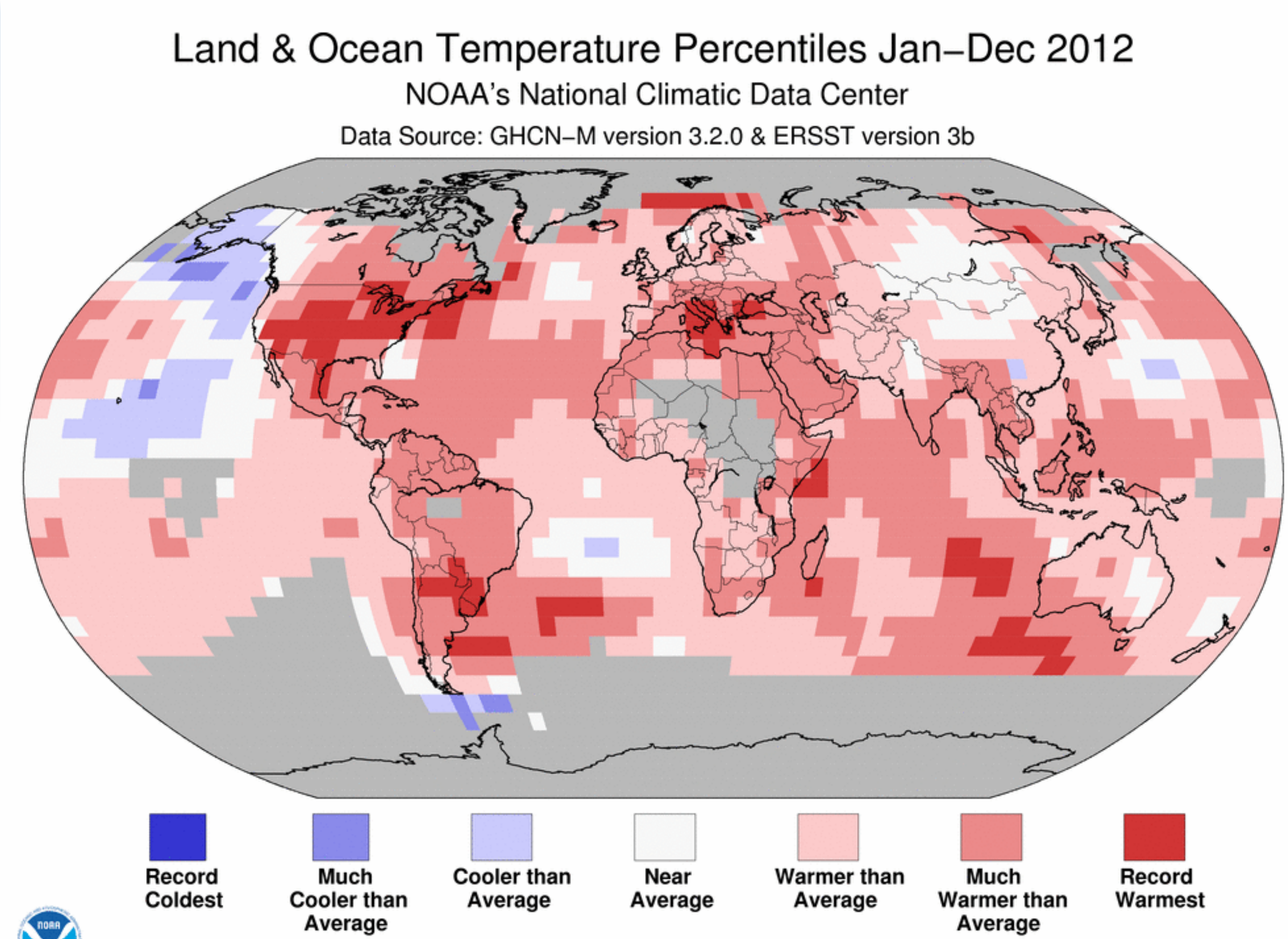


11 Indicators of a Warming World

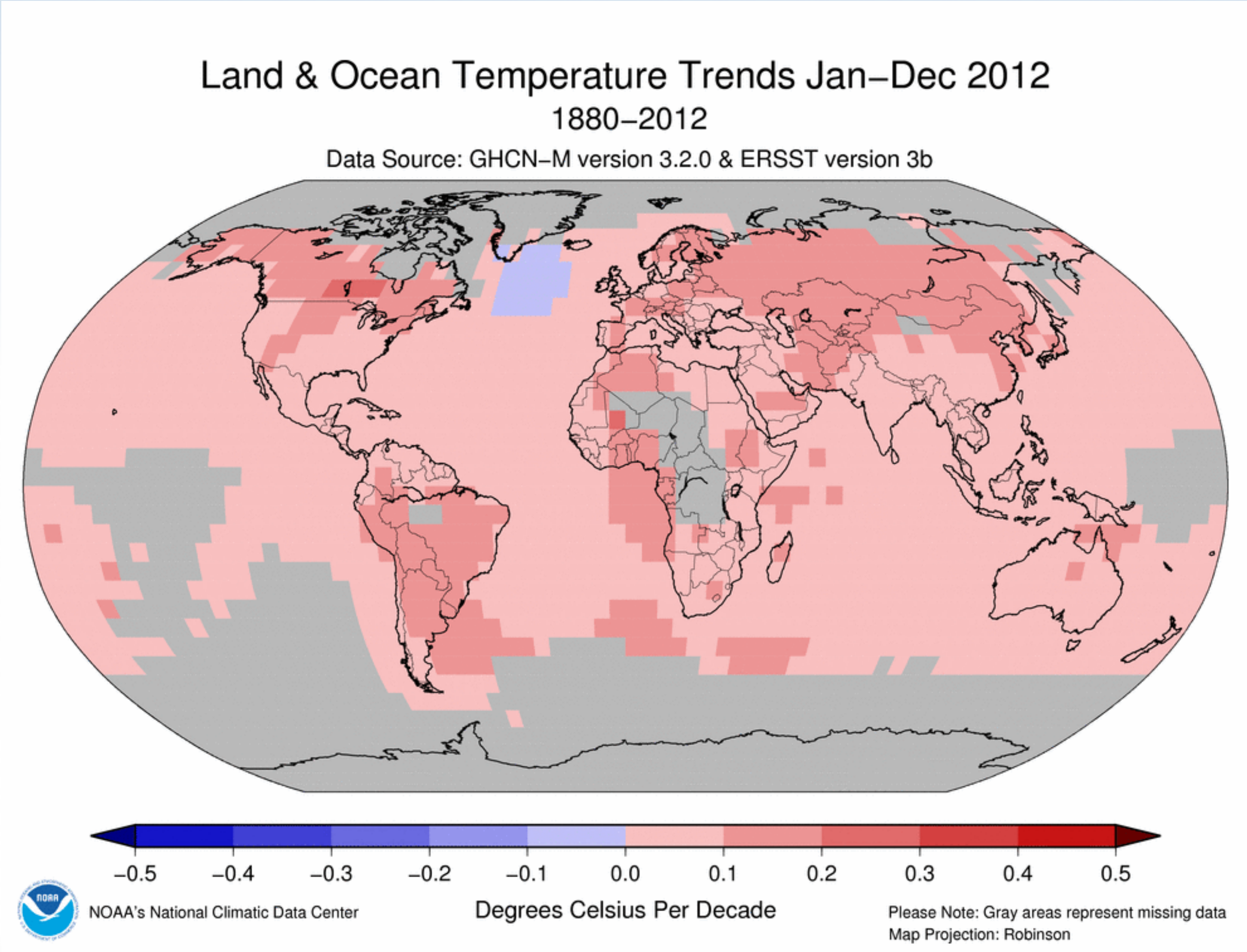
The stratosphere (up here!) is cooling



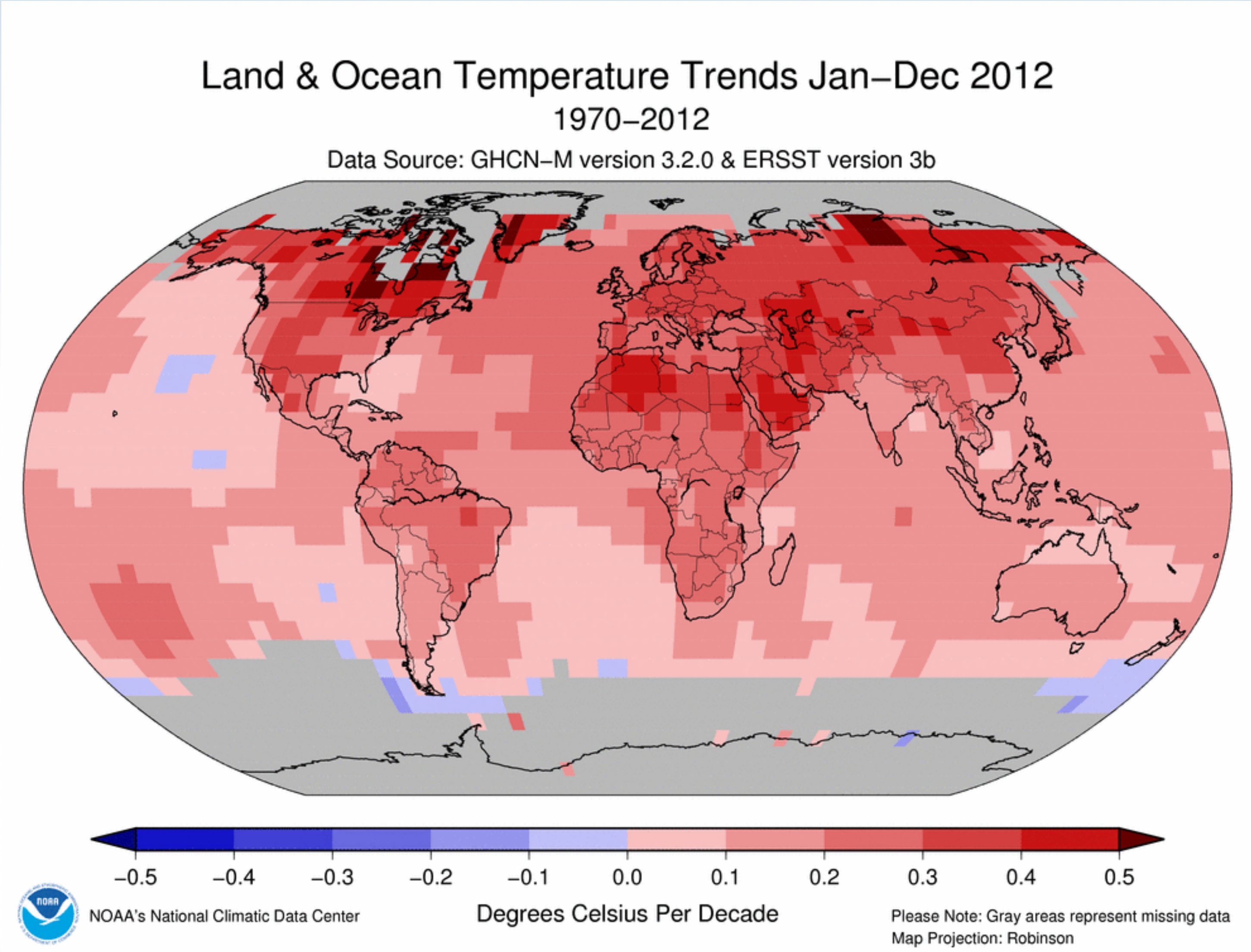
Global Climate Highlights: 2012



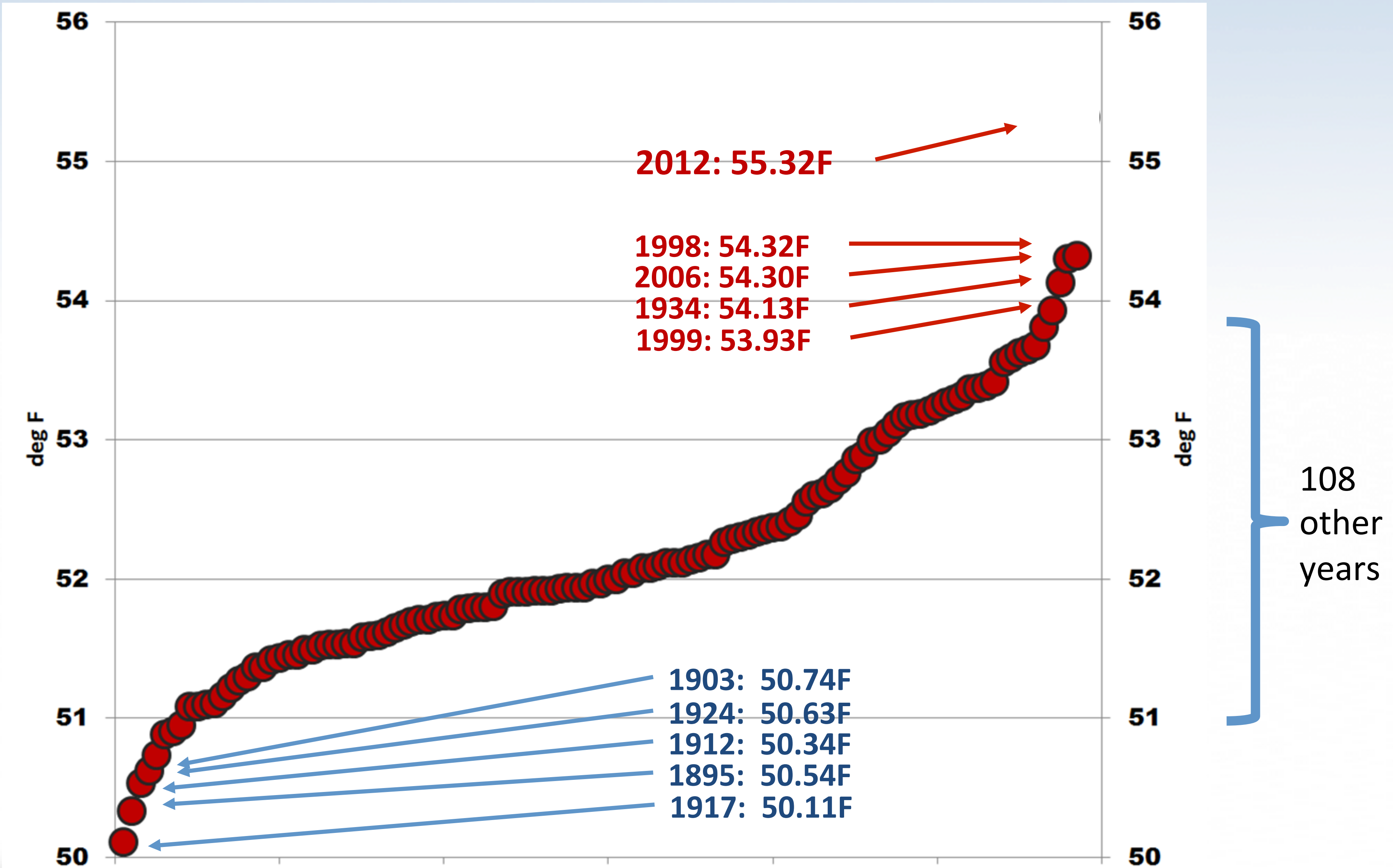
Trends since 1880



Trends since 1970

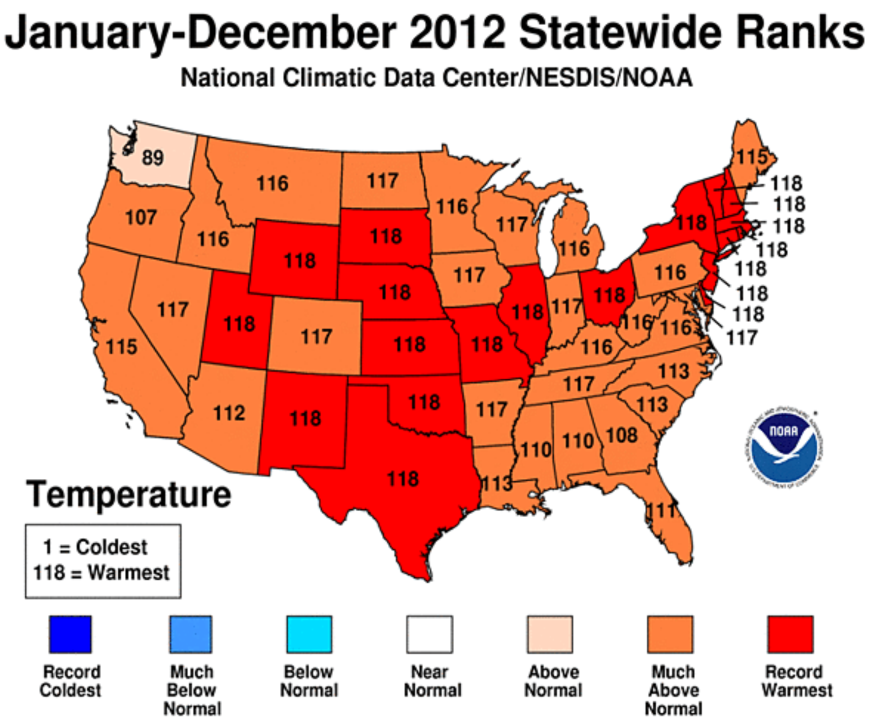


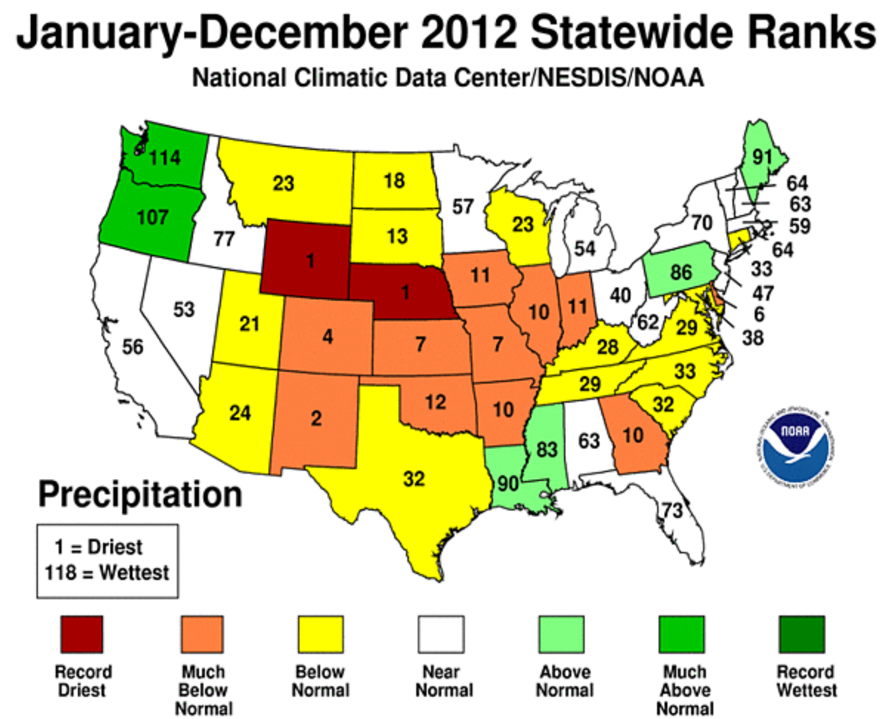
Warmest Year on Record for the CONUS



NOAA's National Climatic Data Center

United States Climate Highlights
2012





Big picture Climate Extremes since 2010

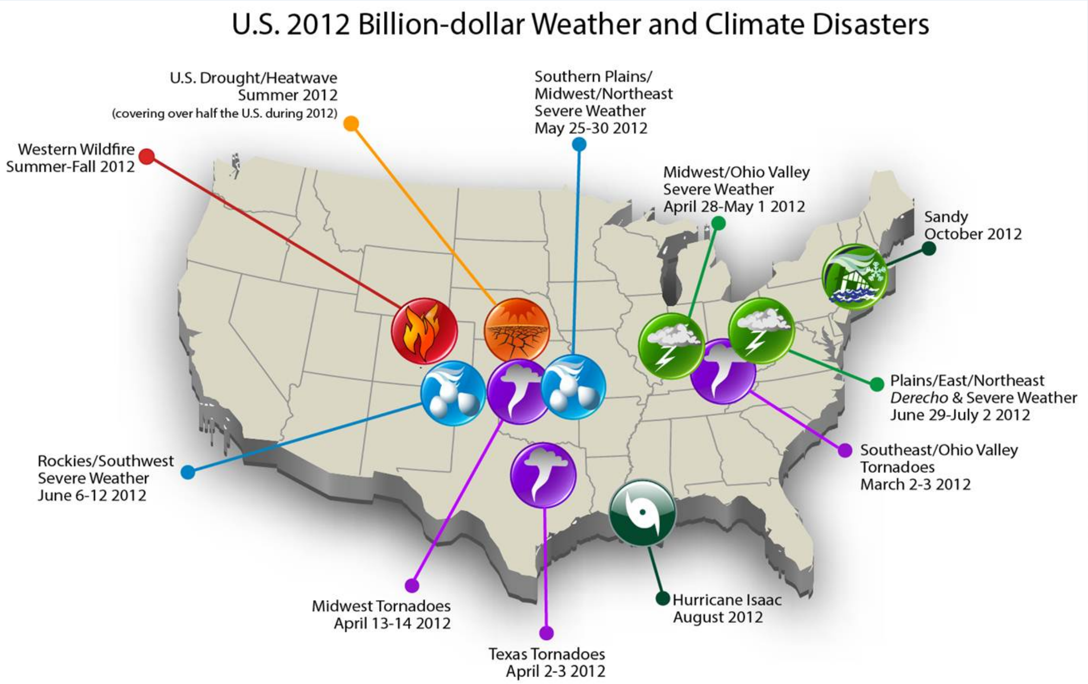
- Mar 2010: MA NJ RI
- Apr 2010: IL NJ CT RI ME
- May 2010: LA
- Jun 2010: DE LA* MD NC NJ RI VA IA MI
- Jul 2010: DE RI
- Aug 2010: FL* LA*
- Sep 2010: NM MN
- Oct 2010: FL
- Dec 2010: FL GA NV UT
- Apr 2011: IL IN KY NY OH PA WV
- Jun 2011: LA TX NM
- Jul 2011: OK TX
- Aug 2011: AZ CO FL LA NM OK TX NH NJ NY VT
- Sep 2011: OR PA
- Mar 2012: CONUS AR CT GA IL IN IA KS KY MI MN MS MO NE NH NJ NY OH OK PA RI SC SD TN VT WV WI WY CO
- Jun 2012: CO WY FL
- Jul 2012: CONUS VA
- Aug 2012: NV NE WA WY
- Sep 2012: MN MT ND SD

WARMEST COOLEST
WETTEST DRIEST

- 1Q 2010: FL ME NH* VT*
- Spr 2010: CT* MA* ME MI* NH* NJ* NY* RI VT*
- 2Q 2010: CT DE LA MA ME MD NC NH NJ RI VA
- Sum 2010: AL DE FL GA MD MS NC NJ RI SC TN VA WI
- 3Q 2010: FL MA WI
- 4Q 2010: NV FL
- CY 2010: NH* RI* ND
- Spr 2011: IN KY MT NY OH PA VT WA WV WY TX
- 2Q 2011: OR WA TX IN KY MI OH NM
- Sum 2011: LA NM OK TX CT NJ TX
- 3Q 2011: NM TX MD NJ VT
- Aut 2011: OH PA
- 4Q 2011: MA NH RI VT
- CY 2011: CT IN KY NJ NY OH PA
- 1Q 2012: CONUS CT DE IA IL IN KS KY MA MI MN MO ND NH NJ NY OH OK PA RI SD TN VA VT WI WV CT
- Spr 2012: CONUS AL AR CO CT DE GA IA IL IN KS KY LA MA MD MI MN MO MS NC NE NH NJ NY OH OK SC SD TN TX VA VT WI WV WY DE
- 2Q 2012: CO KS AR
- Sum 2012: CO WY FL NE WY
- 3Q 2012: NV WY MS MT NE SD
- Aut 2012: NV
- CY 2012: CONUS CT DE IL KS MA MO NE NH NJ NM NY OH OK RI SD TX UT VT WY NE WY

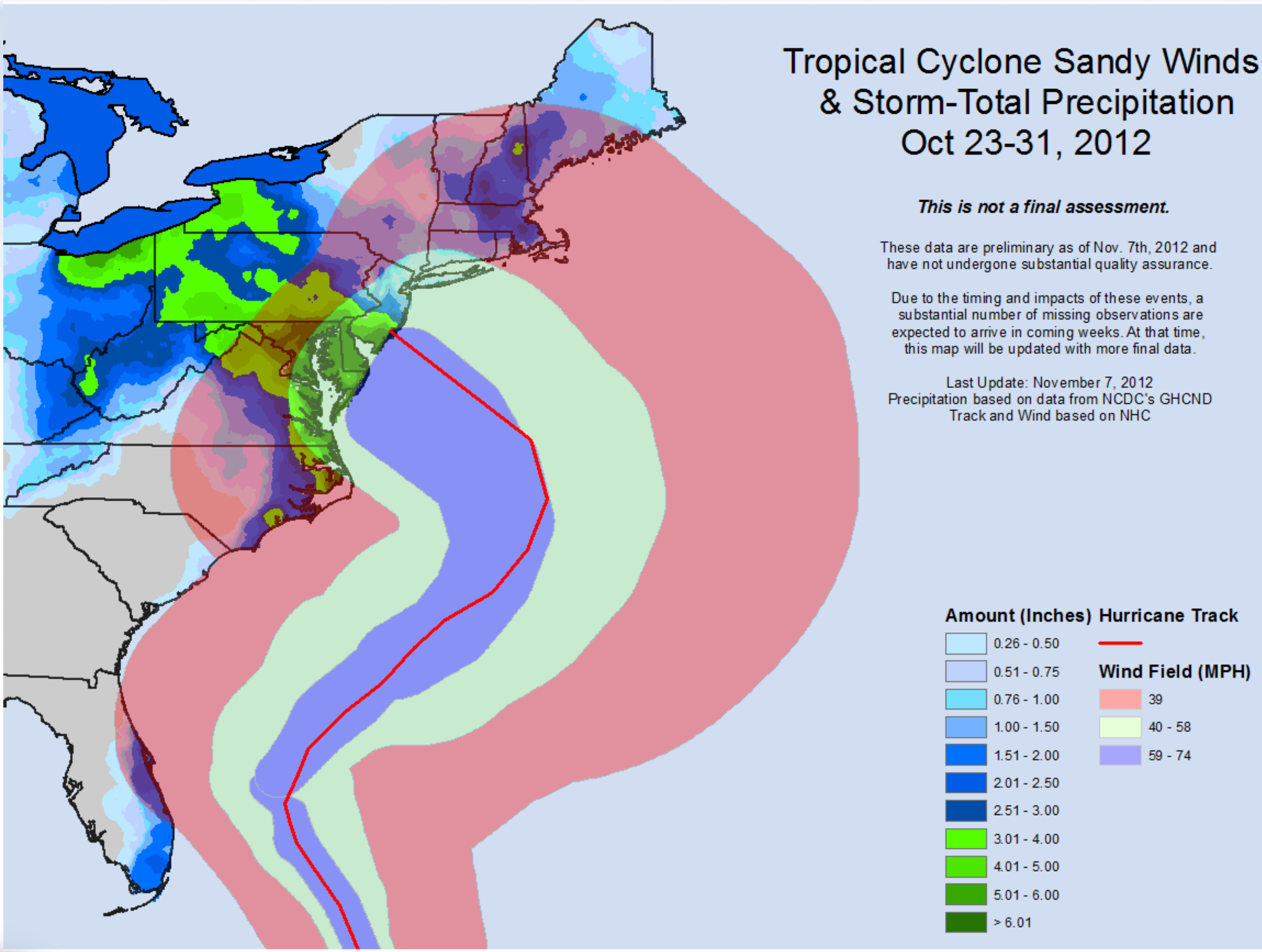
"Billion Dollar Disasters"

- At least 10 events in 2012
- Down from 2011 (which was likely unprecedented)
- Combination of factors: both the physical (weather) events, and the value of the targets



Post-tropical cyclone Sandy Impacts

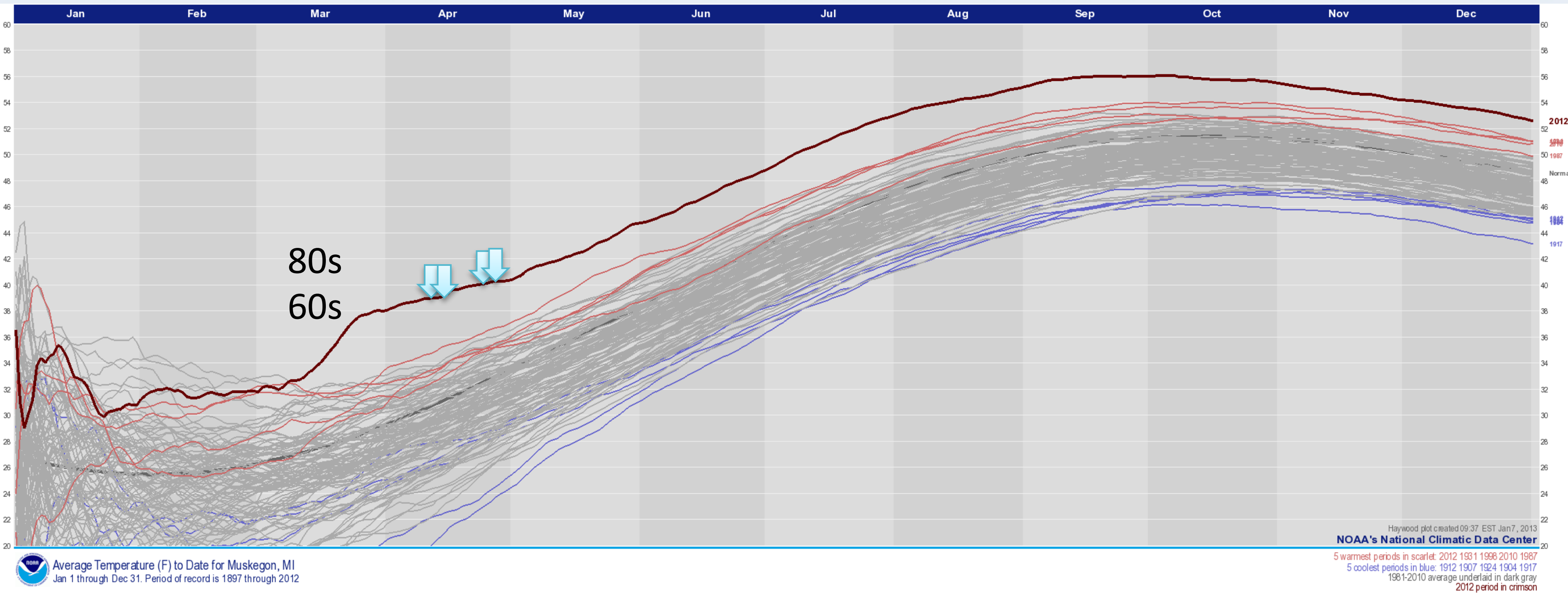
Precipitation Totals



July 23, 2010: Vivian, SD

Image courtesy Aberdeen, SD WFO

Muskegon, MI

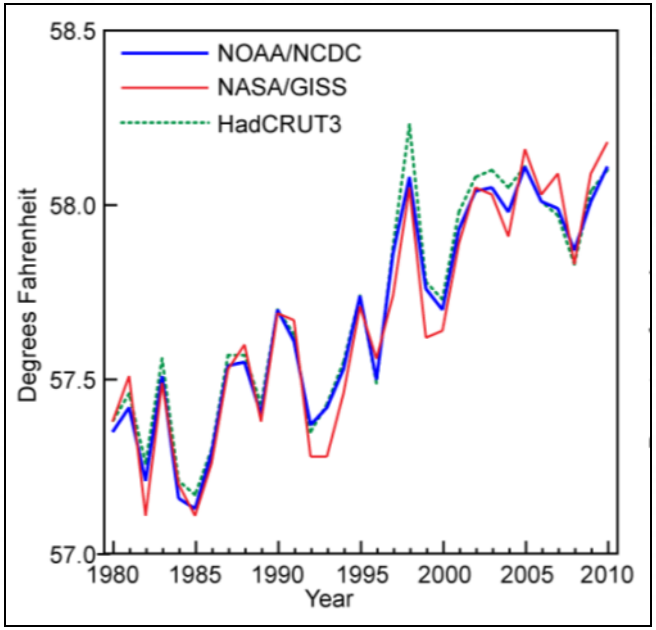


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
80s
60s
2012
1987
1917
Haywood plot created 09:37 EST Jan7, 2013
NOAA's National Climatic Data Center
Average Temperature (F) to Date for Muskegon, MI
Jan 1 through Dec 31. Period of record is 1897 through 2012
5 warmest periods in scarlet: 2012 1931 1998 2010 1987
5 coolest periods in blue: 1912 1907 1924 1904 1917
1981-2010 average underlaid in dark gray
2012 period in crimson

PART II:

The [general] relationship between [extreme] weather and climate

Weather vs. Climate: *Like the Stock Market*

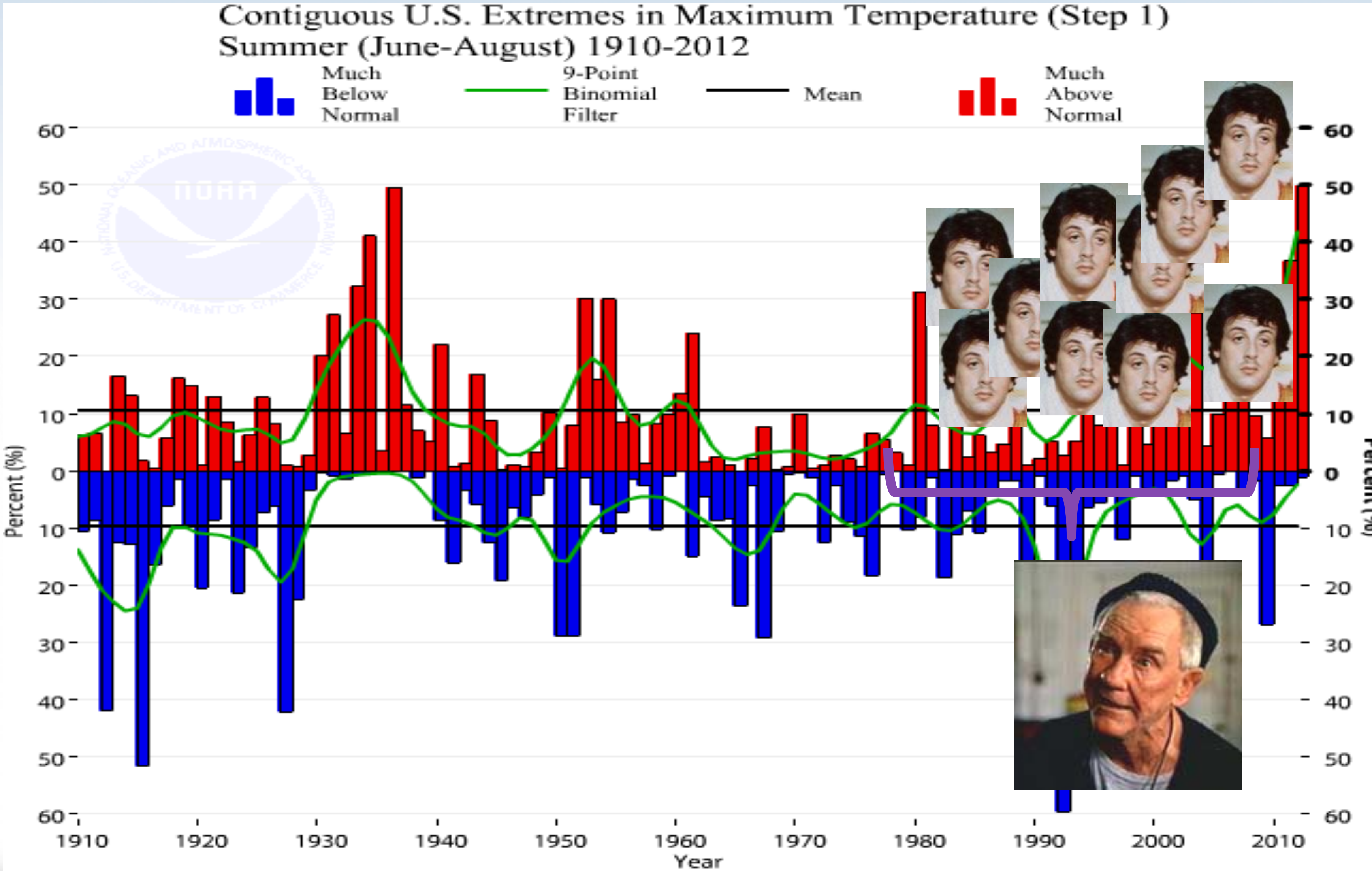


Relationship between weather & climate

Literature Review: Stallone et al. (1976)

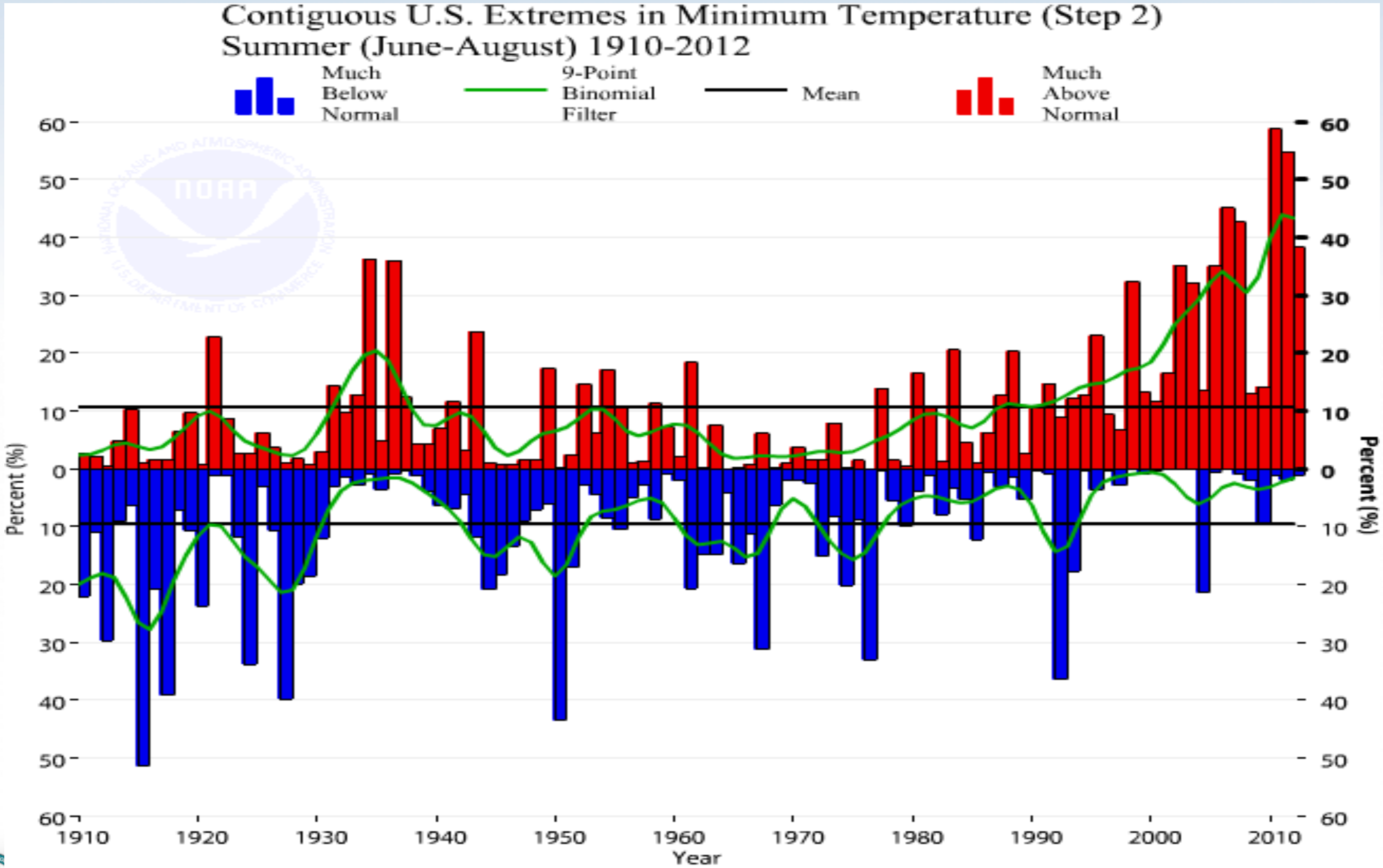
US Climate Extremes

summer minimum temperatures

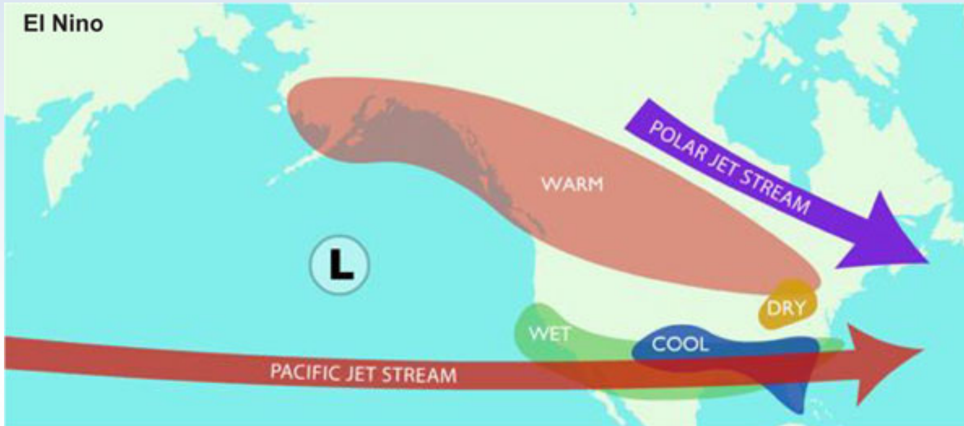


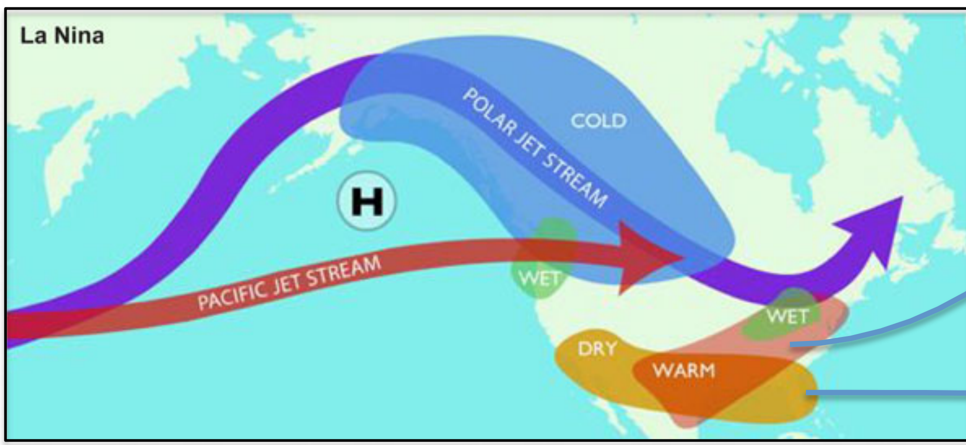
US Climate Extremes

summer minimum temperatures

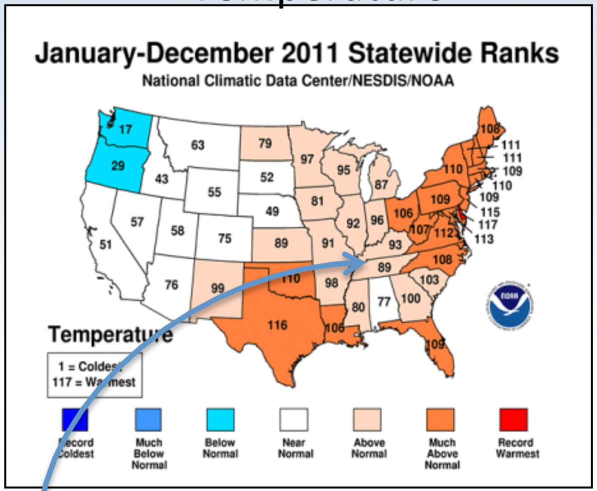


El Niño and La Niña: Effects on the United States

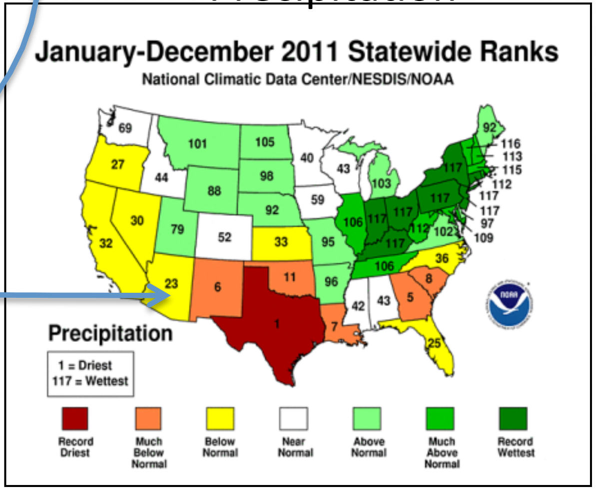




Temperature



Precipitation

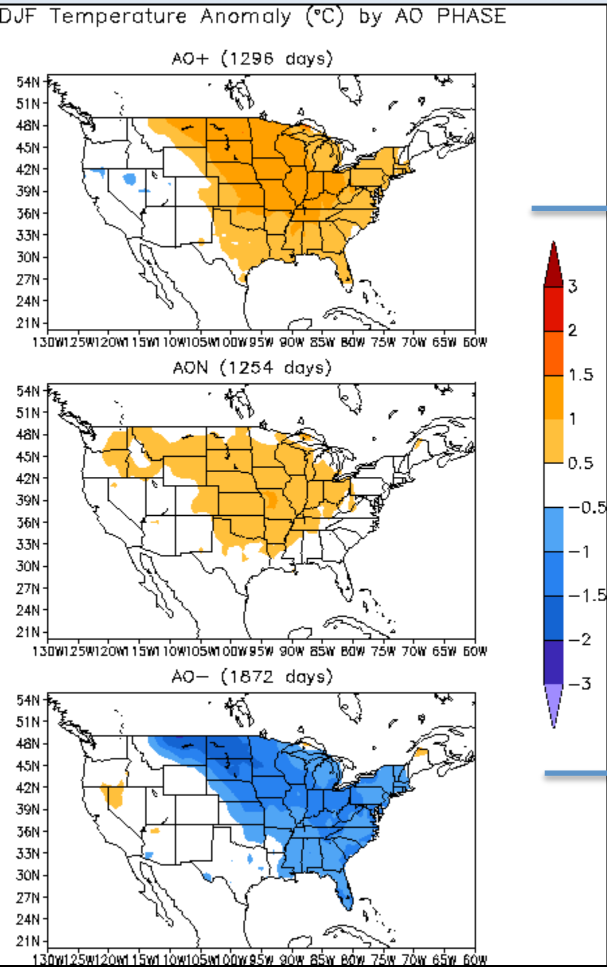


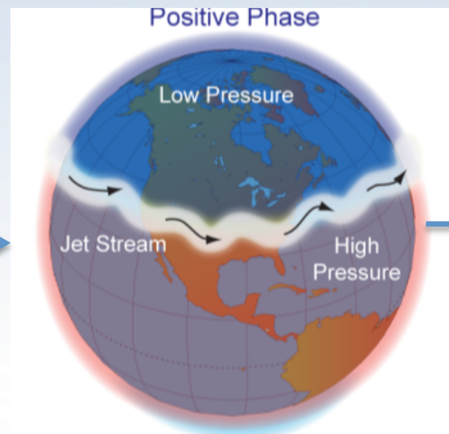
Strongest effects are felt in winter months

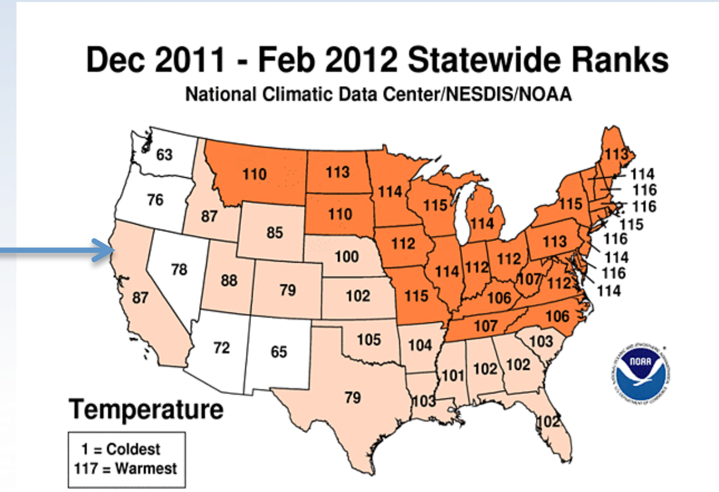
The Arctic Oscillation: Effects on Temperatures in the United States

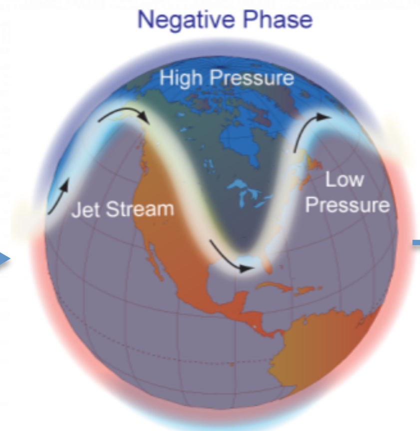
Winter Months

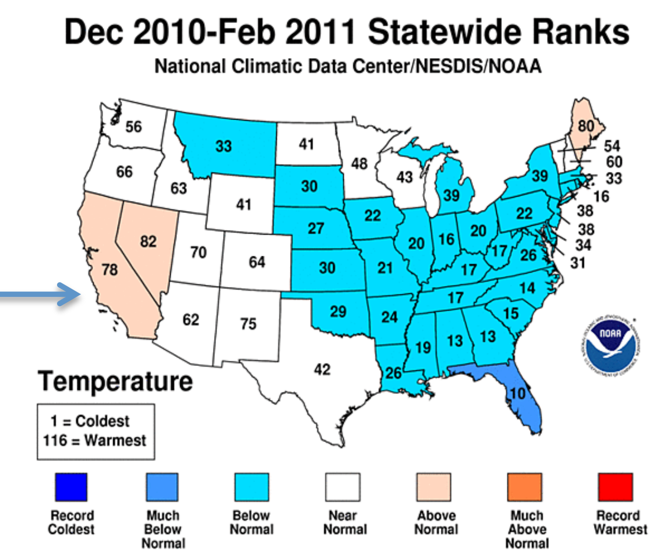
December, January, February











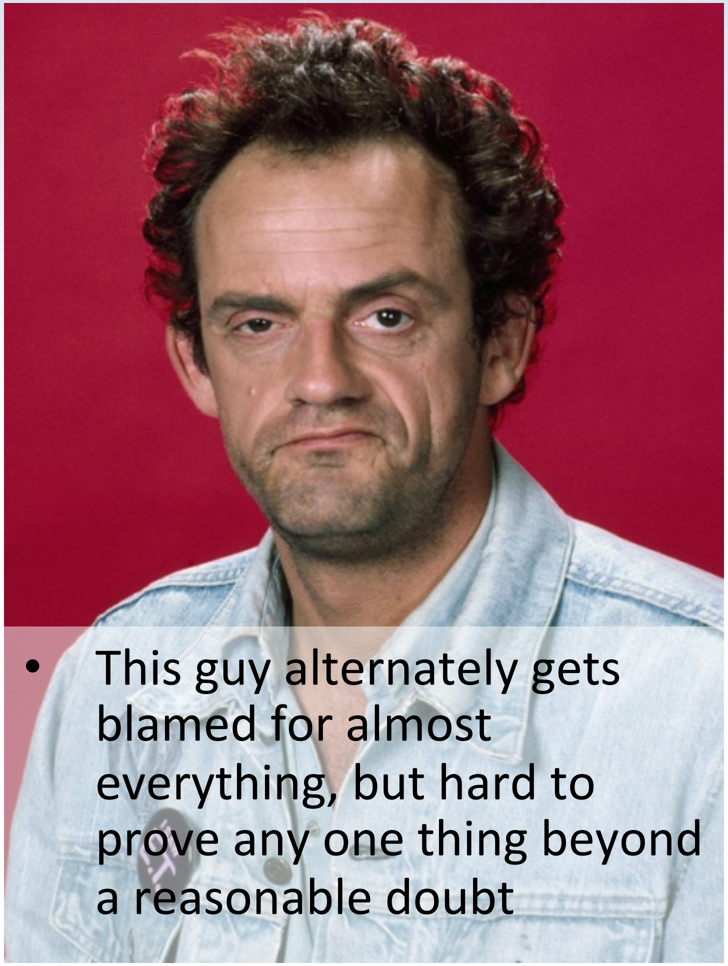
Climate and Extreme Weather

- Kinda impulsive
- Short attention span
- Very sensitive to his environment
- Prone to occasional extreme behavior, given the "right set of ingredients"
- Forgets quickly, "moves on"
- Let's call this kid weather

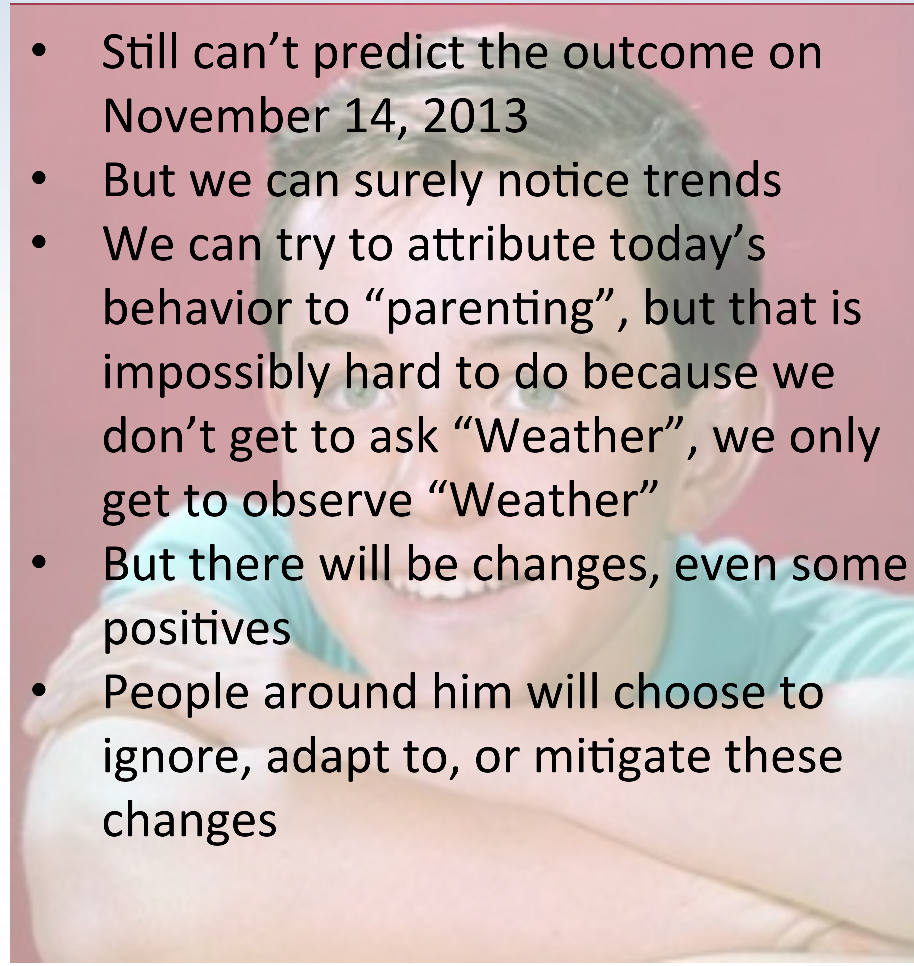
Climate and Extreme Weather

- Still impulsive
- Still responds mostly to his immediate environment
- Still spends months at a time hanging out with his influential friends "La Nina" and "el Nino"
- But seems to be getting into weird situations more often
- The drivers of his individual days are mostly similar
- The trajectory of his life has changed

Climate and Extreme Weather



- This guy alternately gets blamed for almost everything, but hard to prove any one thing beyond a reasonable doubt



- Still can't predict the outcome on November 14, 2013
- But we can surely notice trends
- We can try to attribute today's behavior to "parenting", but that is impossibly hard to do because we don't get to ask "Weather", we only get to observe "Weather"
- But there will be changes, even some positives
- People around him will choose to ignore, adapt to, or mitigate these changes

Thought Experiment

- Which is a more effective, confident way to monitor Beav's behavior (and any actions to change it)?
- "He seems less disruptive lately."
- "He has disrupted the class 23% less often than last month."

PART III:

Specific Hazards

Extreme Events

- How we detect, count and measure extreme events has changed, for each event, since the mid-20th Century.

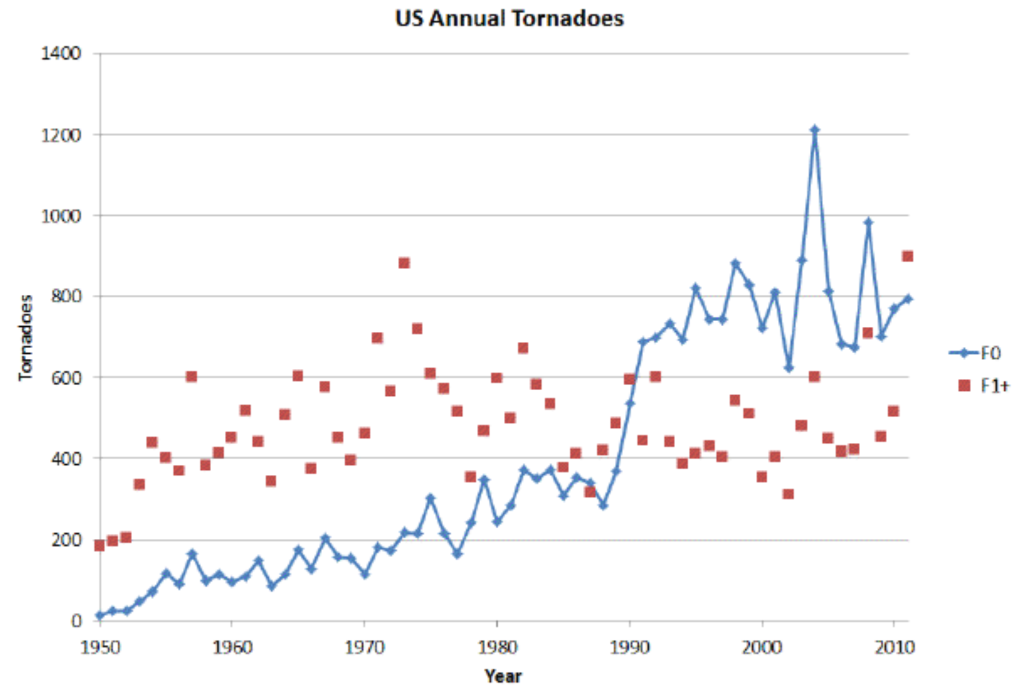


Figure 1. Reported tornadoes in NWS database from 1950-2011. Blue line is F0 tornadoes, red dots are F1 and stronger tornadoes.

Extreme Events

- Extreme events are borne from a set of ingredients.
- Tracking *the* ingredients is very useful!

Violent Local Weather: Ingredients

- Instability
  - Several flavors, but generally related to warm, moist air low in the atmosphere, cold, dry air higher in the atmosphere
  - High Instability: powerful updrafts
- Wind shear
  - Changing of wind speed and/or direction as you go up
  - High wind shear: well-organized, long-lived t-storms and related phenomena
- Tornadoes need very high wind shear, generally

Violent local weather: Trends

- Difficult to establish long-term trends because we're so much better at predicting/verifying than we used to be
- The instability ingredient is likely increasing / will increase
- The shear ingredient, in the long term, decrease
- Some "long term trends vs. game day" issues

July 23, 2010: Vivian, SD

Image courtesy Aberdeen, SD WFO

Kansas State record Hailstone

Photos from National Weather Service, Wichita, KS WFO. Credits: Frank Kotsch and Melissa McCarter

Hurricanes

- Ingredients
- Warm water
- Supportive shear profile

Hurricanes / TCs

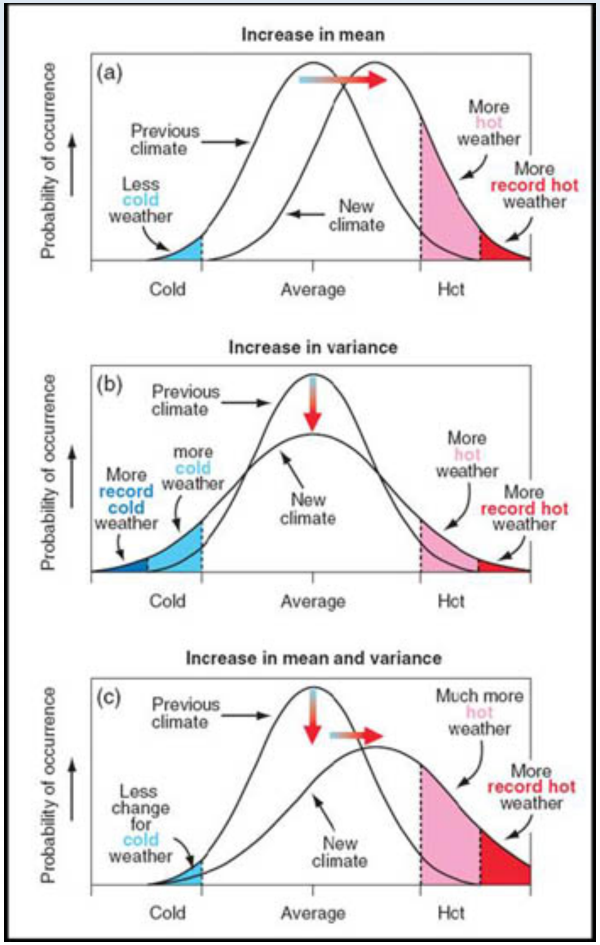
- Still considerable scientific work to be done to determine trends of TC frequency
- Slightly more confidence that TCs will become more intense (on average) in certain basins
- Sea level is rising, this makes the impact of a given TC potentially more destructive

Heat Waves / Extreme Heat

- Ingredients:
  - Entrenched warm air
  - “blocking patterns” keep “ridges” in place, reinforcing the warmth

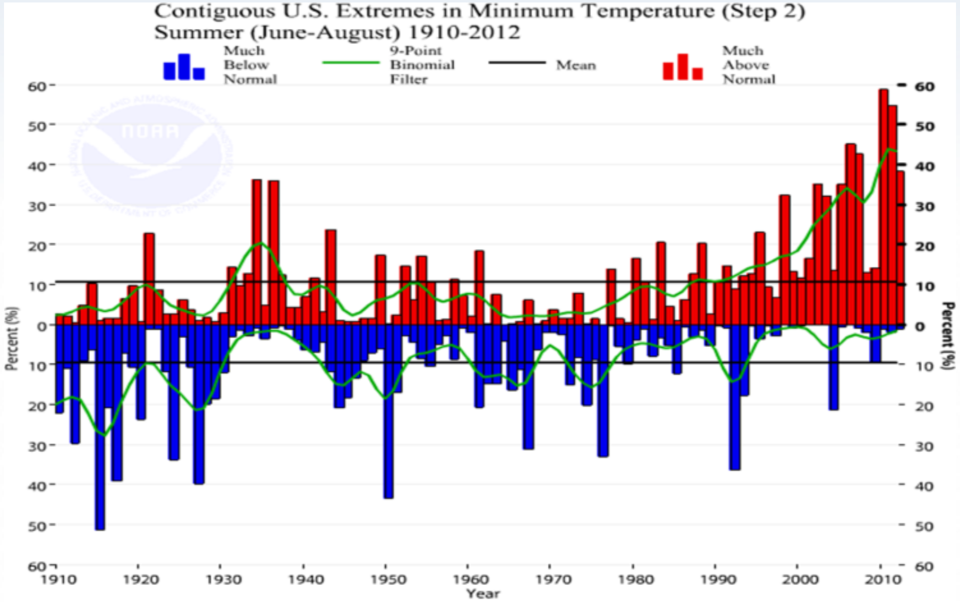
Heat Waves / Extreme Heat

- Heat waves defined in many different ways, depending on affected population
- The data are in great shape in the USA
- The Gist: extreme heat is one of the "easy ones". There will be more extreme heat …



Heat Waves / Extreme Heat

- Heat waves defined in many different ways, depending on affected population
- The data are in great shape in the USA
- The Gist: extreme heat is one of the "easy ones". There will be more extreme heat … and there already is



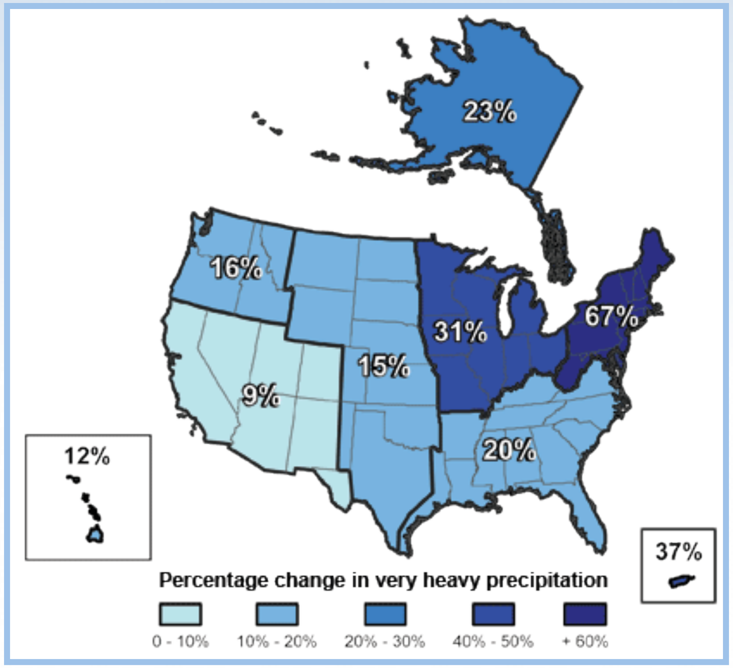
Flooding / Extreme Precipitation

- Ingredients for Extreme Precipitation:
  - Sufficiently moist air
  - Sufficient "lift" or rising motion

Extreme Precipitation

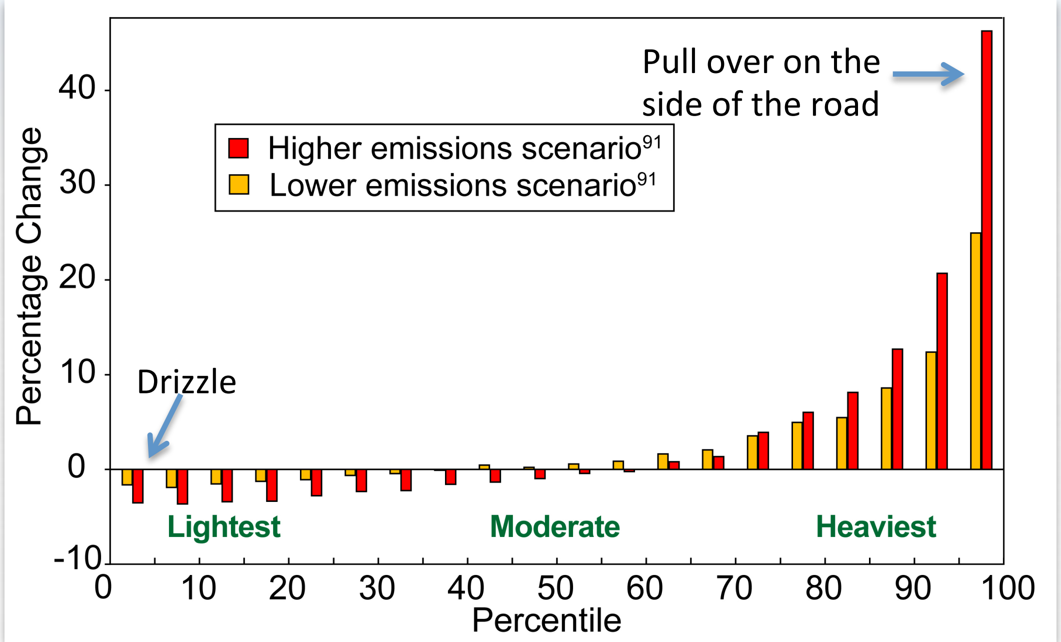
- Another one of the "easy ones"
- Rule of thumb (works often, not always) for general precipitation in a changing climate: wet places/seasons/phenomena get wetter; dry places/seasons/phenomena get drier
- For the most part, the data are in great shape, and support this

2. Climate changes are underway in the U.S. and are projected to grow



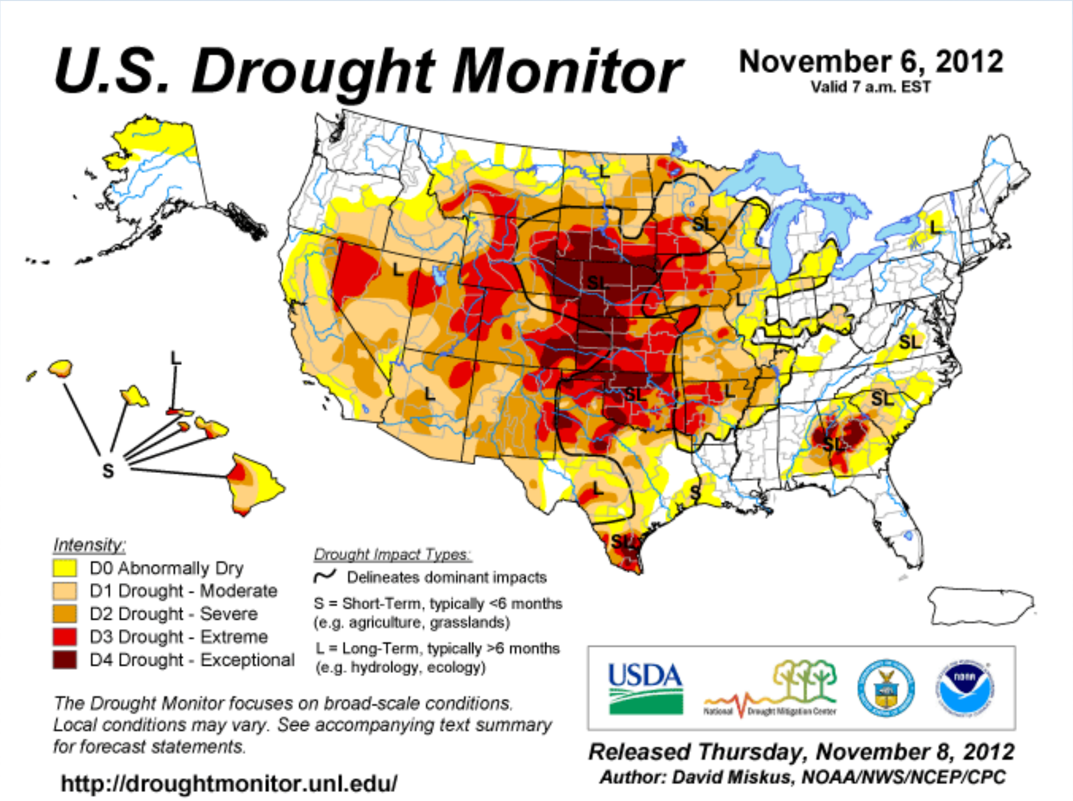
Observed Increases in Very Heavy Precipitation (1958 to 2007)

Projected Change in Precipitation Intensity (2080-2099)

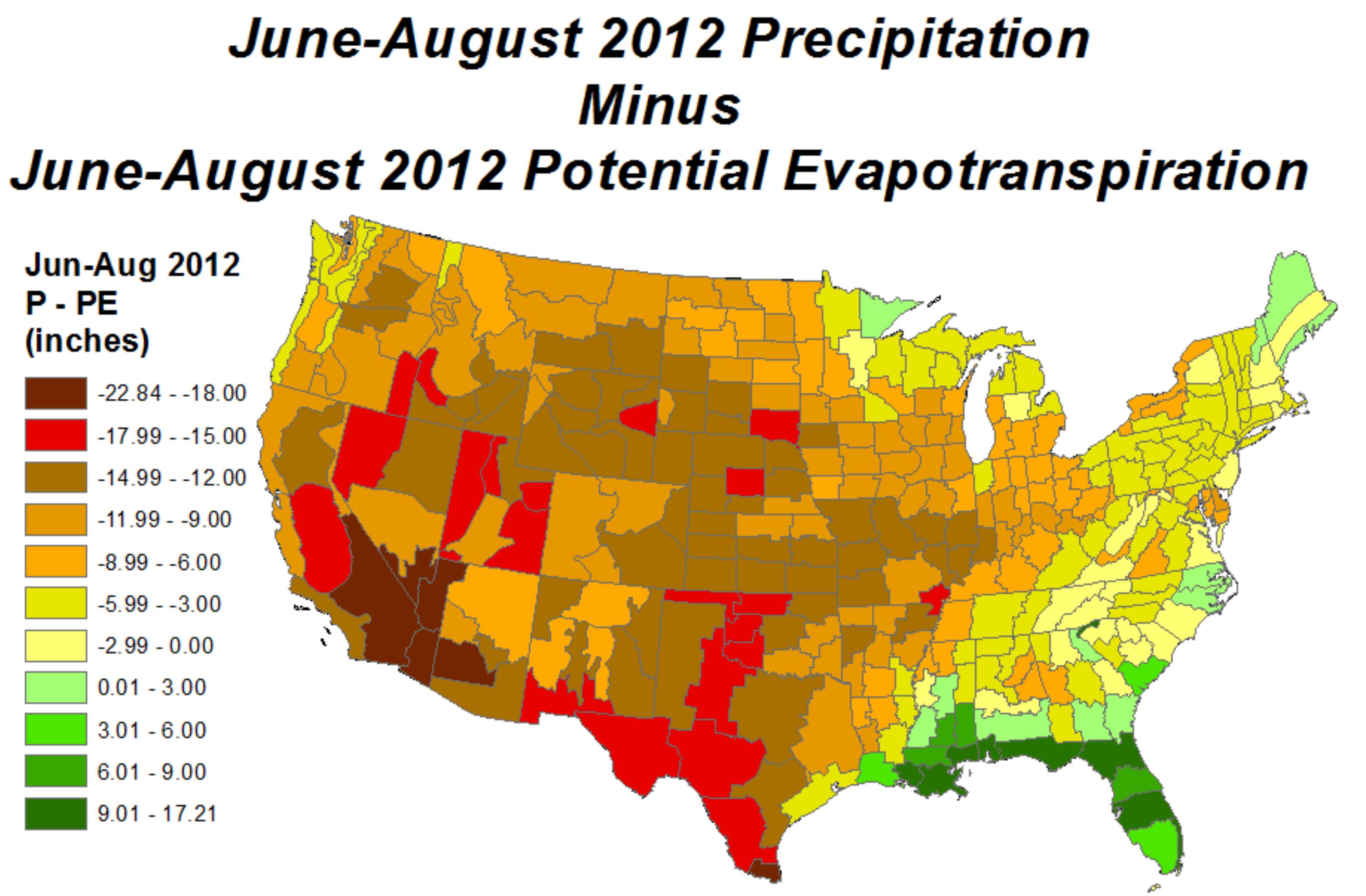


Drought

U.S. Summer Heat & Drought



U.S. Summer Heat & Drought



Summary

- Climate and weather have, in some ways, a teacher-student, parent-child, coach-athlete relationship
- Climate affects weather outcomes by changing the frequency and nature of how ingredients come together
- We are seeing changes in the mean
- We are seeing changes in certain types of extreme weather
- We can quantify these changes with ***data***

Thank you for your time!

- Deke Arndt
- Derek.Arndt@noaa.gov