



Technology and Trends in Weather and Climate

Helping business mitigate the challenges of increasingly volatile weather



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Why does Weather matter?

Weather impacts the economy

-  • “. . . **16.2%** of the aggregate U.S. economy is sensitive to weather on an annual basis” (National Center for Atmospheric Research)
-  • “. . . **1/3** of the private industry activities, representing annual revenues of some \$3 trillion, have some degree of weather and climate risk.” (Penn State University)
- “. . . **\$11 Billion** of losses each year due to weather” (Executive office of President United States)

Weather impacts Ag customers

-  • “. . . **>75%** of all summertime Energy outages are Weather related (lightning)”
-  • “. . . The **single largest variable** in crop yields is Weather”
-  • “. . . . **25%** of all Transportation accidents are Weather related”
-  • “. . . . **>90%** of crop insurance losses are due to Weather factors”

Key Trends in Weather Forecasts

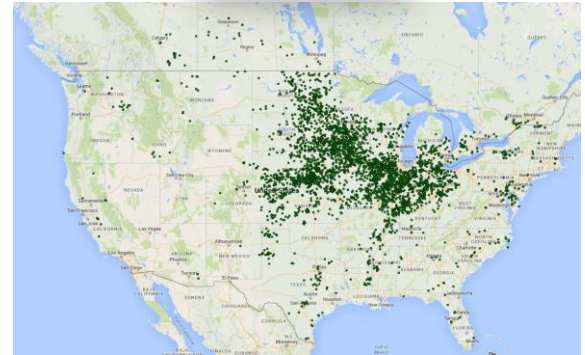
More data and observations

More models and better forecasts

Probabilistic forecasts

More Data and Observations

- **Today:** Growing public/private weather station networks
 - Thousands of stations – DTN's Local Weather Station network
 - Updating every 5-60 minutes
- **Tomorrow:** Connected vehicles
 - Millions of observations
 - Updating every 5-60 seconds
- **The Future:** Mobile devices
 - Millions upon millions of observations
 - Updating in real-time!



DTN Local Weather Station Network - 3,500 stations

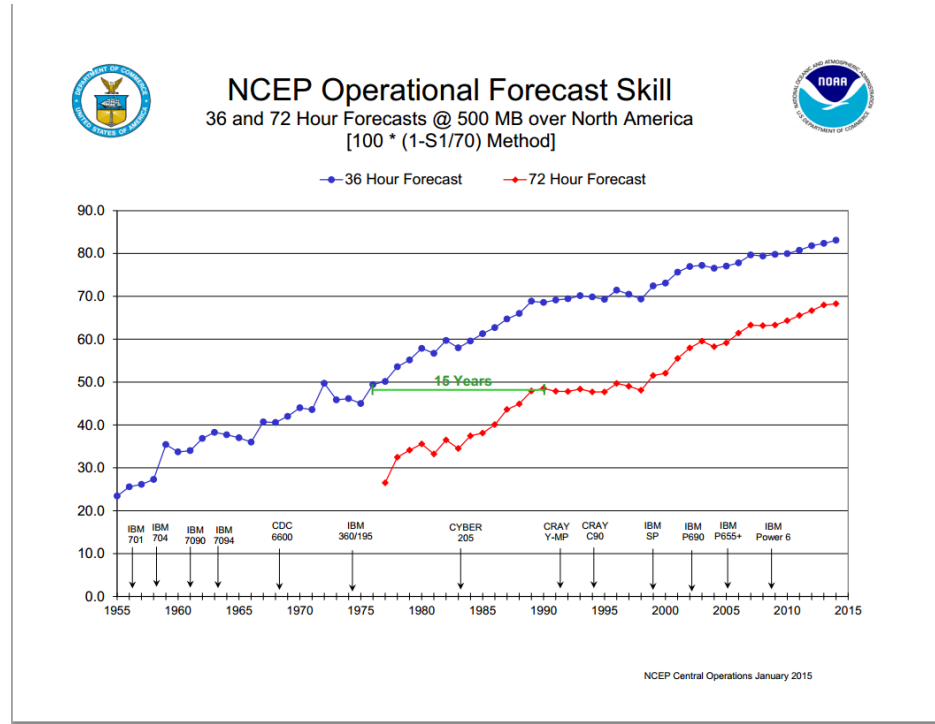
- **More observations = better forecast accuracy**

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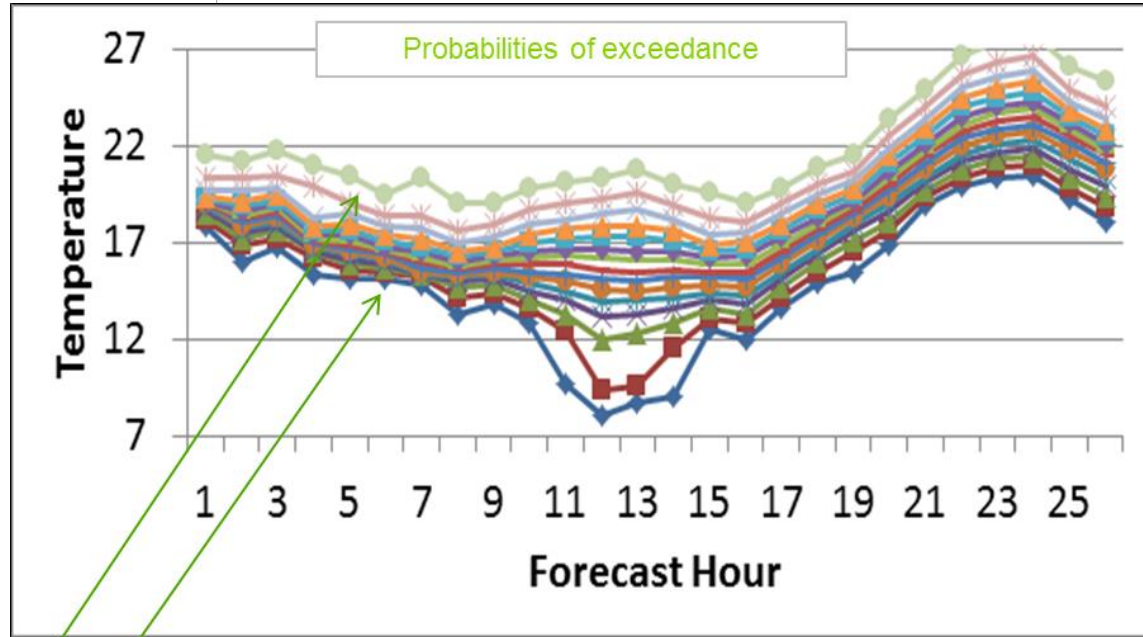
More models and better forecasts

- More weather models
 - More centers
 - US NWS, ECMWF, Env. Canada, Australian BoM....
 - Higher resolutions
 - By 2016, 10km global resolution
 - By 2020, 4km global resolution
 - Higher data volumes
 - Halving the resolution is a 4X increase in volume
- Better weather forecasts
 - Forecast skill doubles every 15 years
 - Today, forecasts have skill out to 8 days
 - By 2020, forecasts will have skill out to 10 days



Probabilistic information adds value to forecasts

- Weather forecasts are inherently uncertain
 - However, understanding the probabilities can aid in decision making
 - The increasing amount of observational and model data make probabilistic forecasts better
- Precipitation
 - What does a 50% chance mean?
 - Are there better ways to communicate uncertainty?
- Probability of Exceedance
 - Probability that a specific event will occur



P5 – 5% chance that temp will exceed this value

P95 – 95% chance that temp will exceed this value

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Technology is driving weather forecast improvements

- More and better (and cheaper) observations
- Bigger and faster computers
- Integration of weather data into decision support apps



Trends in climate impacts

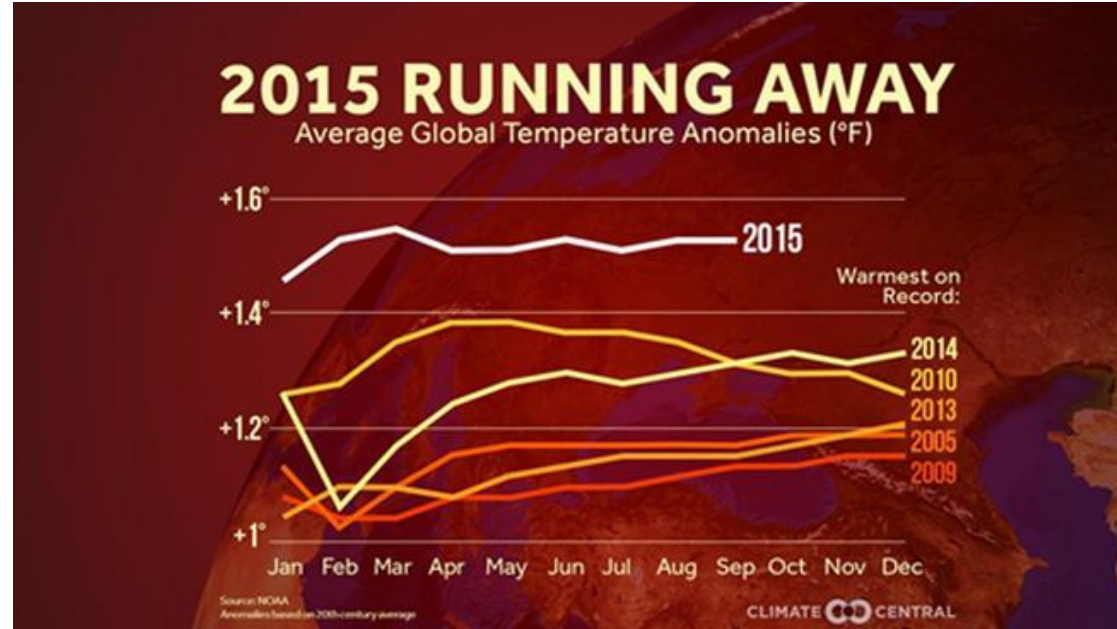
Increased volatility and vulnerability

More extreme weather events

Continued impacts to weather and water businesses

What about 2015?

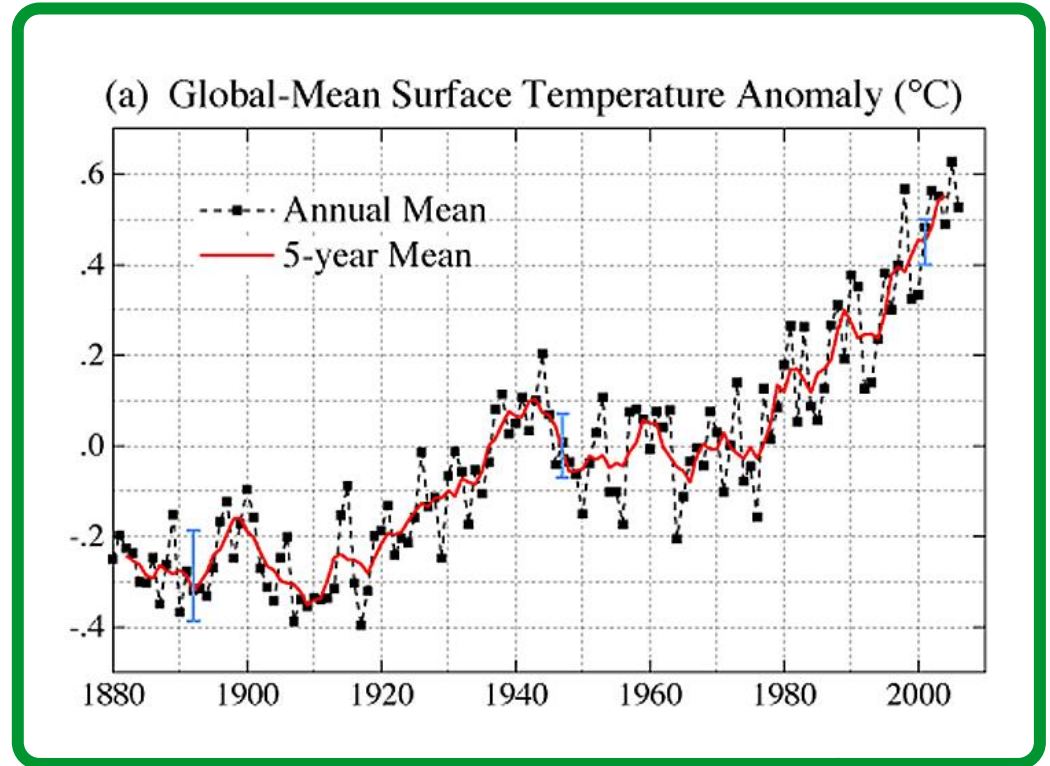
- Likely to be the warmest year on record
 - Proximate Cause: One of the three strongest El Nino's ever recorded
- What is the relationship to climate?



Source: NOAA

Weather and Climate

- Climate is weather over years and years
 - “Climate is what you expect, and weather is what you get.”
- The climate is changing, but climate change is nothing new
 - Surface warming is likely to continue
- One of the consequences of climate change is an increase in volatility



Increased volatility and vulnerability

- Extreme weather events are occurring with increased frequency
 - Could be forced by arctic warming
- Increased exposure and vulnerability
 - Increased urbanization
- More persistent weather patterns

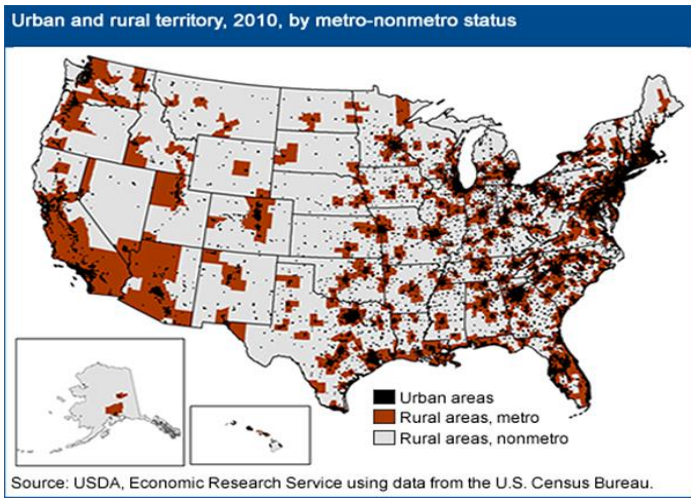
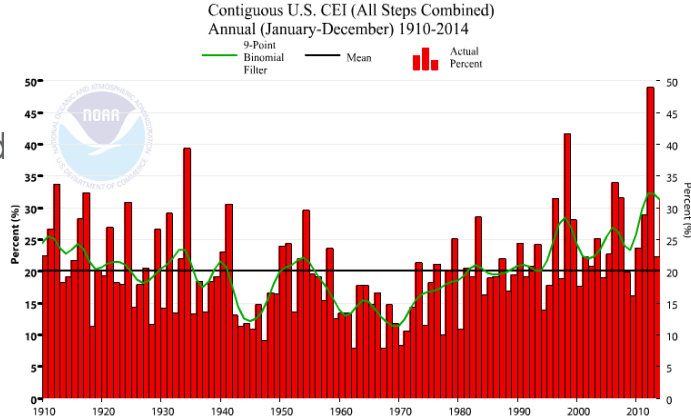
Slower, wavier jet stream



Strong polar vortex:
faster jet stream winds

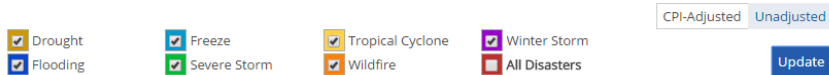


Weak polar vortex:
slower winds, more waves

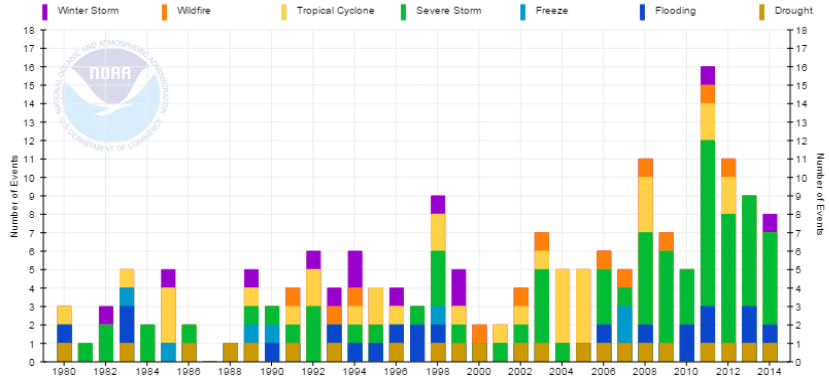


More extreme weather events

- The frequency of extreme weather events will increase
- The cost of these events will rise
- This trend is likely to continue for several decades



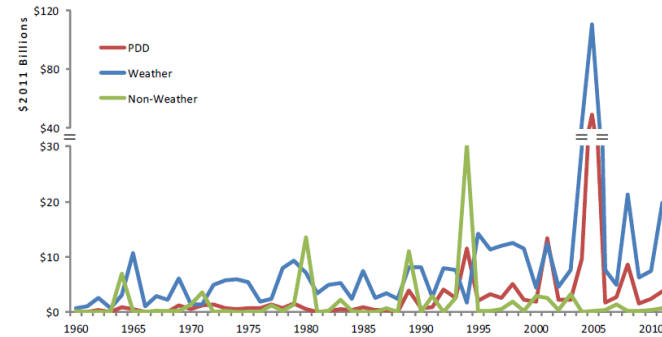
Billion-Dollar Disaster Event Types by Year (CPI-Adjusted)



SUMMARY OF LOSSES

Year	Total Losses (\$2011 billion)	Fatalities*	Injuries*	Property (\$2011 B)	Crop (\$2011 B)
1960 - 2011	670.8	30,441	227,230	544.9	125.9
Annual Average	12.9	585	4,370	10.5	2.4

ANNUAL LOSSES & PRESIDENTIAL DISASTER DECLARATIONS (PDD)

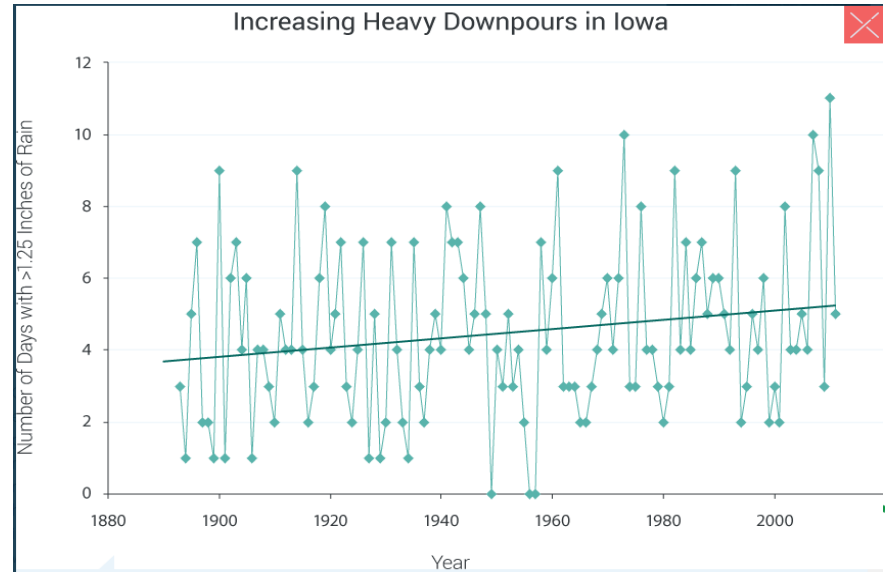
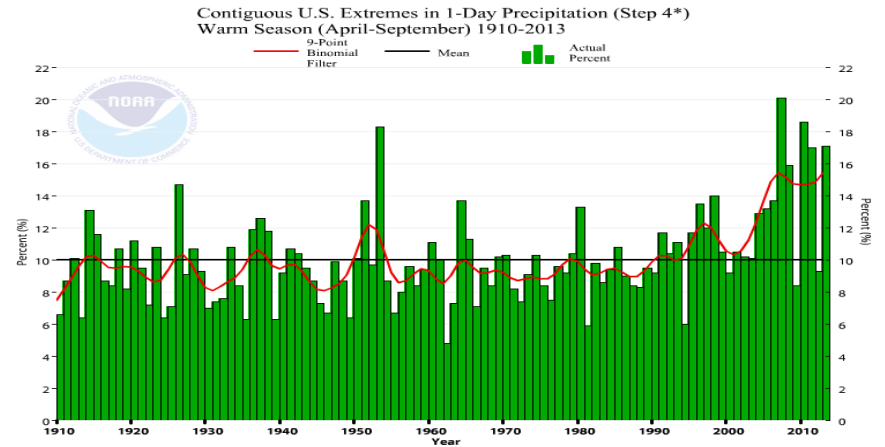


15 COSTLIEST YEARS

Year	Total Losses (\$2011 billion)	Fatalities*
2005	115.4	1,256
1994	33.2	476
2004	31.5	338
1980	24.5	1,055
2008	23.9	485
1989	23.9	635
2011	23.8	1,019
1998	23.2	672
1995	19.7	1,608
1990	18.6	482
2001	17.1	445
1999	16.2	920
1993	15.8	393
1996	14.7	537
1997	13.9	583

Continued impacts to agriculture

- Impacts
 - More excessive rainfall events
 - More flooding
 - Increased drought severity and extent
 - More frequent and intense coastal storms and hurricanes
 - More Black Swan events
- Preparation is key
 - Risk awareness
 - Use of forecasts
 - Integration into decision aids



Questions?