Antitrust Notice

- The Casualty Actuarial Society is committed to adhering strictly to the letter and spirit of the antitrust laws. Seminars conducted under the auspices of the CAS are designed solely to provide a forum for the expression of various points of view on topics described in the programs or agendas for such meetings.
- Under no circumstances shall CAS seminars be used as a means for competing companies or firms to reach any understanding – expressed or implied – that restricts competition or in any way impairs the ability of members to exercise independent business judgment regarding matters affecting competition.
- It is the responsibility of all seminar participants to be aware of antitrust regulations, to prevent any written or verbal discussions that appear to violate these laws, and to adhere in every respect to the CAS antitrust compliance policy.

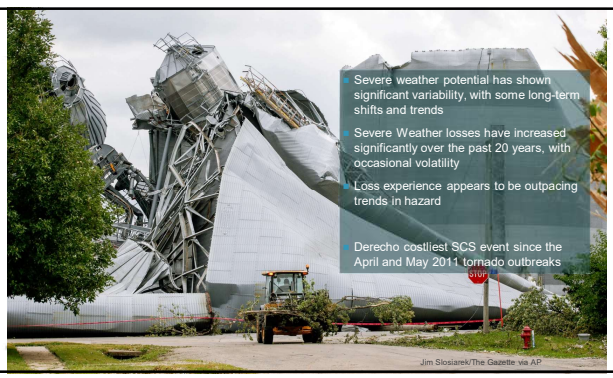
1

RenaissanceRe
Risk Sciences

Severe Convective Storms

David Hamilton
Senior Scientist
Raleigh, NC

2



- Severe weather potential has shown significant variability, with some long-term shifts and trends
- Severe Weather losses have increased significantly over the past 20 years, with occasional volatility
- Loss experience appears to be outpacing trends in hazard
- Derecho costliest SCS event since the April and May 2011 tornado outbreaks

3

Outline

- Severe Convective Storms (SCS)
  - Climatology
  - SCS Hazard Trends vs Variability
  - SCS Losses vs SCS Hazard Data
- 2020 Iowa Derecho


KOAA News

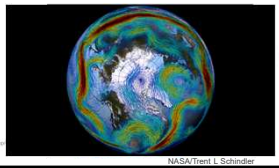

NY Times

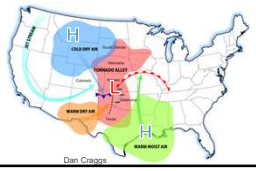

Ryan Lenz

4

Severe Convective Storms (SCS)

- Atmospheric Convection is the "overturning" of the lower atmosphere, producing:
  - Tornadoes
  - Hail
  - Straight Line Winds
  - Heavy Rain
- Predominant modes of SCS activity driven by jet stream amplification
  - Drives cold air southward
  - Dropping surface pressure, forcing warm moist air from Gulf of Mexico towards surface low pressure
  - Attendant vertical wind shear sustains long lived and intense convection


NASA/Trent L Schindler

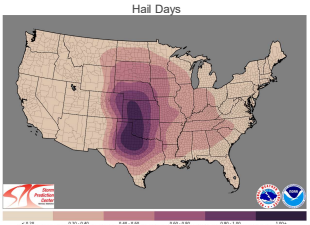


Dan Craggs

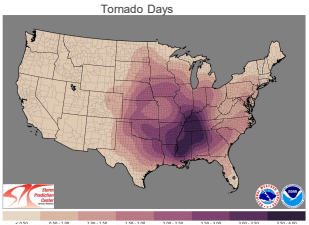
5

Significant Hazard Climatologies

Hail Days


Mean Number of Hail >2.00" Days per Year
Within 25 Miles of a Point
1986 - 2015

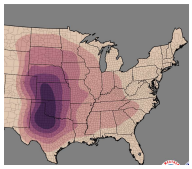
Tornado Days

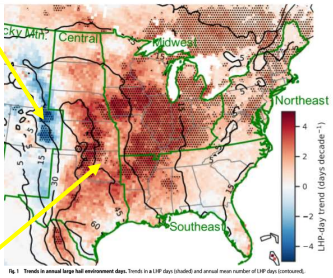

Mean Number of EF2+ Tornado Days per Decade
Within 25 Miles of a Point
1986 - 2015

6

Trends in Large Hail Potential Days

Decrease in number of hail days





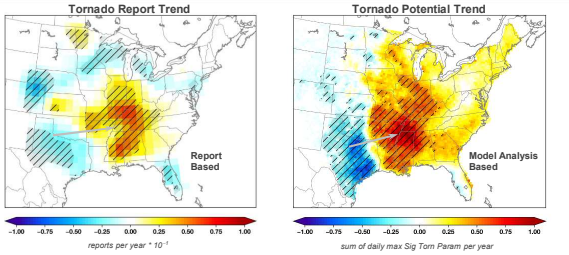
Increase in number of hail days

Fig. 1 **Trends in annual large hail environment days.** Trends in a LHP days (shaded) and annual mean number of LHP days (contoured).

B.H. Tang, et al. 2019

7

Shifts in Tornadoes and Tornado Potential



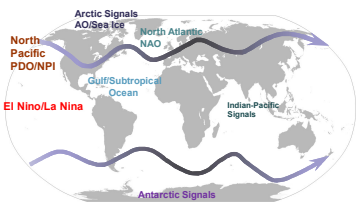
- Reports and Modeled trends in the period 1979-2017

Gensini and Brooks, 2018

8

Large Scale: Jet Stream

- Jet streams are the dominant atmospheric force on mid-latitude weather systems
- Jet wave patterns often modified by global climate signals
- ENSO, AO/NAO, and PDO are significant climatic modulators of North American weather

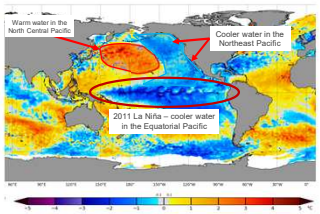


9

Pacific Decadal Oscillation (PDO)

- Anomalous sea surface temperatures in North Pacific
  - Cold or warm phases last about 20 to 30 years.
- ENSO (El Niño/Southern Oscillation) events typically persist for 6 – 18 months
- Negative PDO and La Niña bring stronger northwesterly winds to the Northwest US coast as well as cold Pacific coastal ocean temperatures.

Negative (Cold) PDO and La Niña
Sea Surface Temperature Anomaly
01 January 2011

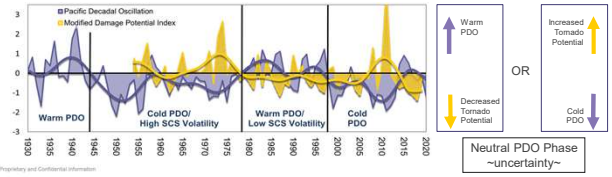


10

Evaluating Risk: Climate Factors

- Evaluation of the natural variability impacting SCS

El Niño - S. Oscillation (ENSO)/Pac. Decadal Osc.(PDO)	North Atlantic Oscillation (NAO)
Negative phases enhance severe weather outbreak Airmass clash/jet phasing Frequency and severity Ohio Valley, Midwest, and C. Plains	Negative phase enhances severe weather potential Enhanced warm/moist low-level Gulf of Mexico flow Ohio Valley, Midwest, and South



Warm PDO → Increased Tornado Potential

OR

Decreased Tornado Potential ← Cold PDO

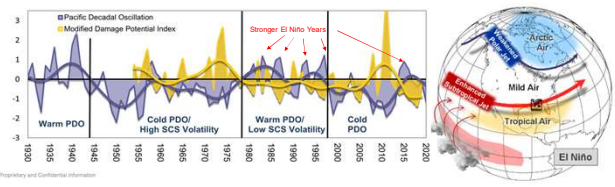
Neutral PDO Phase
~uncertainty~

11

Evaluating Risk: Climate Factors

- Evaluation of the natural variability impacting SCS

El Niño - S. Oscillation (ENSO)/Pac. Decadal Osc.(PDO)	North Atlantic Oscillation (NAO)
Negative phases enhance severe weather outbreak Airmass clash/jet phasing Frequency and severity Ohio Valley, Midwest, and C. Plains	Negative phase enhances severe weather potential Enhanced warm/moist low-level Gulf of Mexico flow Ohio Valley, Midwest, and South

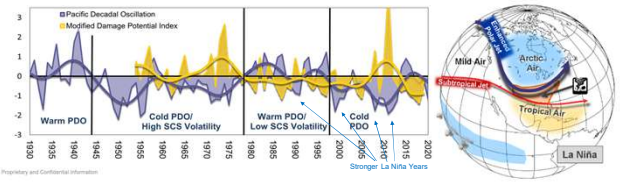


12

Evaluating Risk: Climate Factors

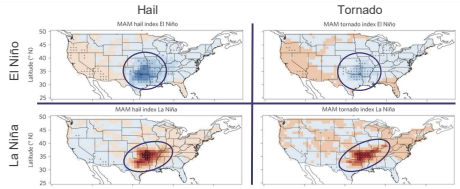
- Evaluation of the natural variability impacting SCS

El Niño - S. Oscillation (ENSO)/Pac. Decadal Osc.(PDO)	North Atlantic Oscillation (NAO)
Negative phases enhance severe weather outbreak Airmass clash/jet phasing Frequency and severity Ohio Valley, Midwest, and C. Plains	Negative phase enhances severe weather potential Enhanced warm/moist low-level Gulf of Mexico flow Ohio Valley, Midwest, and South



13

ENSO: Spring Impacts on Hail and Tornado Anomalies

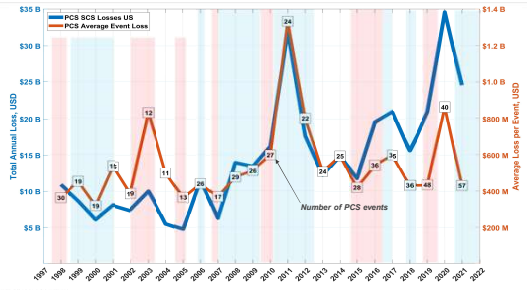


Influence of the El Niño/Southern Oscillation on tornado and hail frequency in the United States
John T. Allen, Michael K. Tippett & Adam H. Sobel
Nature Geoscience 8, 278–283 (2015) doi:10.1038/ngeo2385

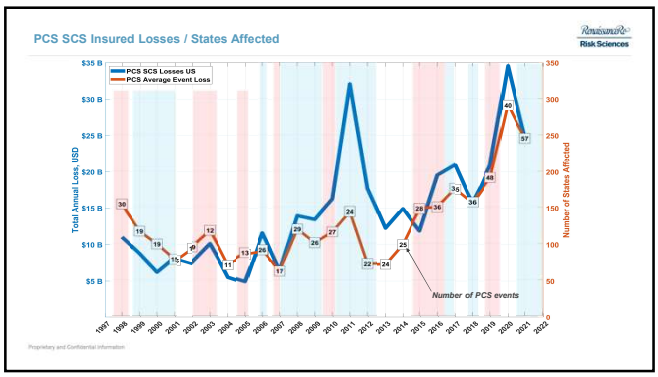
- El Niño is related to significantly **reduced** hail and tornado potential in the Central U.S.
- La Niña is related to significantly **increased** hail and tornado potential in the Central U.S.

14

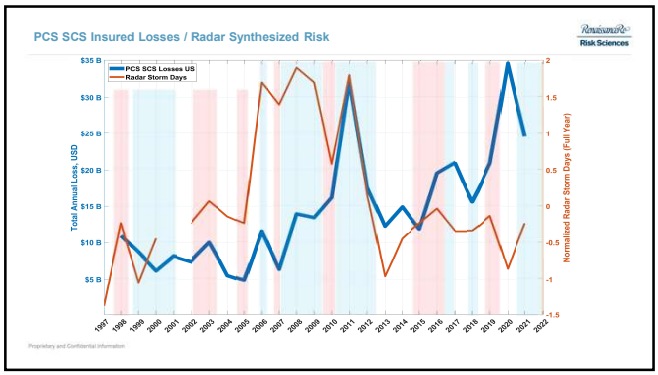
PCS SCS Insured Losses / Average Event Loss



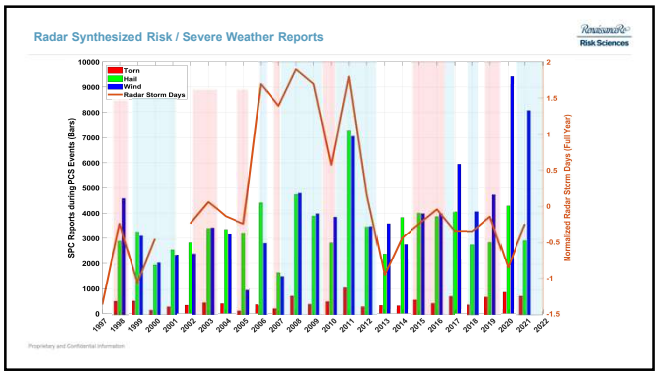
15


PCS SCS Insured Losses / States Affected
RenaissanceRe
Risk Sciences
PCS SCS Losses US
PCS Average Event Loss
Total Annual Loss, USD
Number of States Affected
Number of PCS events
Proprietary and Confidential Information

16


PCS SCS Insured Losses / Radar Synthesized Risk
RenaissanceRe
Risk Sciences
PCS SCS Losses US
Radar Storm Days
Total Annual Loss, USD
Normalized Radar Storm Days (Full Year)
Proprietary and Confidential Information

17


Radar Synthesized Risk / Severe Weather Reports
RenaissanceRe
Risk Sciences
Torn
Hail
Wind
Radar Storm Days
SPC Riports during PCS Events (Bars)
Normalized Radar Storm Days (Full Year)
Proprietary and Confidential Information

18

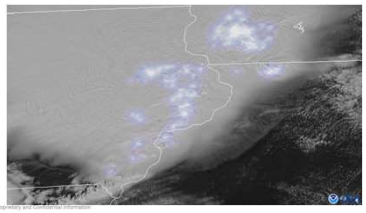
Summary of Part 1

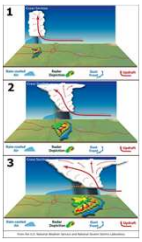
- *Severe weather potential has shown significant variability, with some long-term shifts and trends*
  - Recent research suggests slight changes in potential for tornado and hail in the past few decades
  - Regional hazard behavior correlated with interannual and/or decadal variability, e.g. PDO, La Niña
- *Severe Weather losses have increased significantly over the past 20 years, with occasional volatility*
  - Aggregate losses nearly tripled over 25 years (PCS)
  - The number of PCS events have increased over the past decade
- *Loss experience appears to be outpacing trends in hazard*
  - Event counts and loss increases show some independence from hazard frequency/intensities
  - Overall hail reports have been well below average the past few years (not shown)
  - Wind reports and wind related losses have taken a more prominent role since 2017

19

Derecho (Mesoscale Convective System)

- Large, convective system producing a damage swath over 240 miles from winds of at least 58 mph
  - Often travel hundreds of miles over several hours to a couple of days.
- Propagate analogously to an ocean wave in concert with a cold front or along a stationary front
- 'Squall' line expands with broad and intense gust front
- Produces significant wind damage and flash flooding

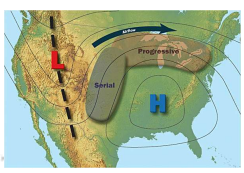


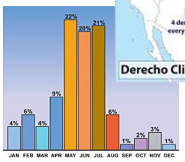


20

Derechos

- Summer-time occurrence associated with strong high pressure over Southeast US.
- Complex in structure and behaves analogously to tropical cyclones:
  - Self-perpetuating
  - Upscale growth
  - Develop large-scale, distinct circulations
- Difficult to forecast in advance
  - Sensitive to subtle atmospheric characteristics
  - Intensity is, generally, unresolved by global, coarse models

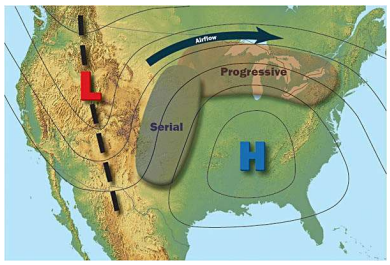




NOAA SPC website/Dennis Cain

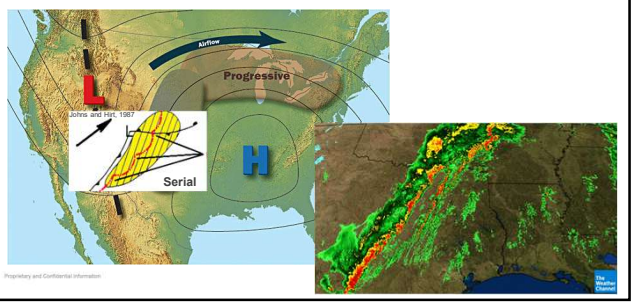
21

Serial vs Progressive Derecho



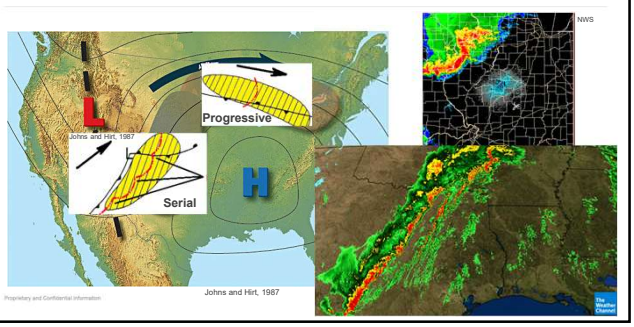
22

Serial vs Progressive Derecho



23

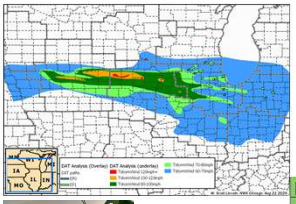
Serial vs Progressive Derecho

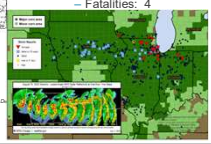


Johns and Hirt, 1987

24

2020 Iowa Derecho (Progressive)





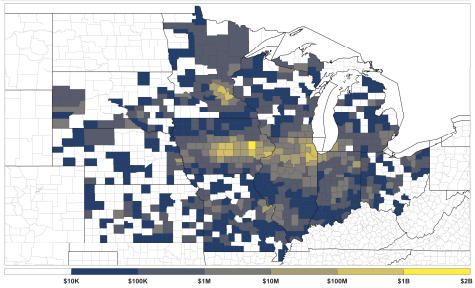
August 10-11, 2020

- PCS: **$8.2 Billion** *insured total,*
  - **$5.2 Billion** *Iowa*
  - **$1+ Billion** *Minnesota, Illinois each*
- USDA Crop: **$271 Million**
- Duration: 14 hours
- Track length: 770 mi
- Peak wind gust:
  - Measured: 126 mph (Atkins, IA)
  - Estimated: 140 mph (Cedar Rapids, IA)
- Largest hail: 2" (Freeport, IL)
- Fatalities: 4

25

PCS Total Estimated Loss Event 2046

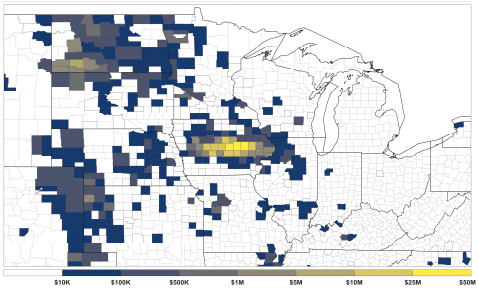
- Linn County, IA
  - Cedar Rapids
  - $2.5 Billion
- Polk County, IA
  - Des Moines
  - $744 Million



26

USDA Cause of Loss Indemnities, Aug 2020 SCS

- Benton County
  - $41 million
- Marshall County
  - $40 million
- Tama County
  - $32 million

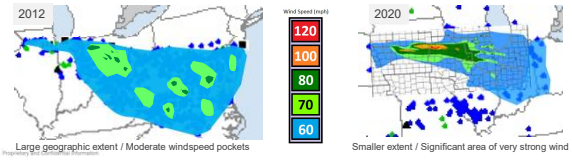


27

2012 Derecho vs. 2020 Derecho (Impact)

June 29-30, 2012
- PCS: **$2.3 Billion** *insured total* (2021 $),
  - **$850 Million** *Ohio*
- 18 *hrs* / 800 *mi*
- Peak wind gust:
  - 91 *mph* (Fort Wayne, IN)

August 10-11, 2020
- PCS: **$8 Billion** *insured total*,
  - **$5.2 Billion** *Iowa*
  - **$1+ Billion** *Minnesota, Illinois each*
- 14 *hrs* / 770 *mi*
- Peak wind gust:
  - Measured: 126 *mph* (Atkins, IA)
  - Estimated: 140 *mph* (Cedar Rapids, IA)

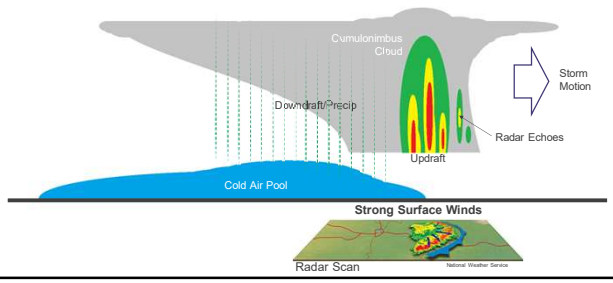


Large geographic extent / Moderate windspeed pockets

Smaller extent / Significant area of very strong wind

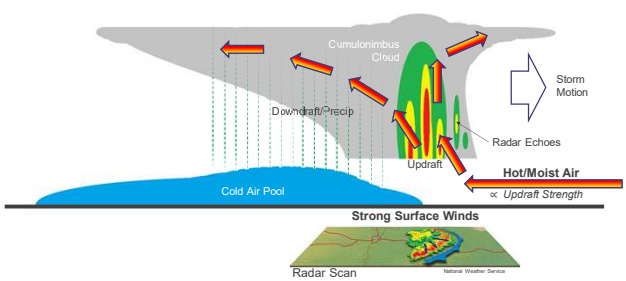
28

MCS Cross Section



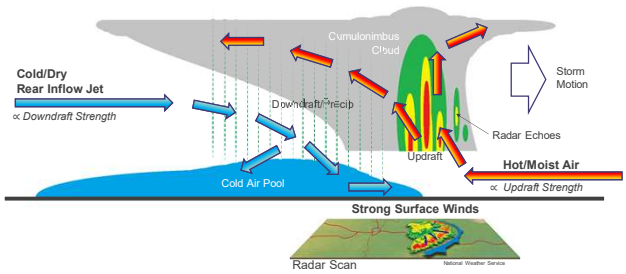
29

MCS Cross Section



30

MCS Cross Section



31

2012 Derecho vs. 2020 Derecho (Forecasts)

- June 29, 2012, 1300 *UTC*

- **SPC text:** *MULTIPLE STORMS … MAY DEVELOP AND GROW … INTO … BOW ECHOES WITH A RISK FOR DAMAGING WINDS AND LARGE HAIL …*

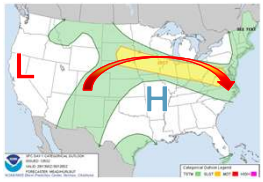
- August 10, 2020, 1300 *UTC*

- **SPC text:** *TRENDS…SUGGEST… A BOW ECHO WITH RISK OF DAMAGING WINDS. WIDESPREAD WIND THREAT MAY ENSUE.*

32

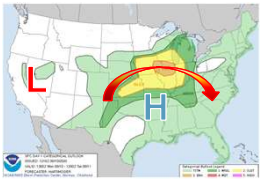
2012 Derecho vs. 2020 Derecho (Forecasts)

- June 29, 2012, 1300 *UTC*



- **SPC text:** *MULTIPLE STORMS … MAY DEVELOP AND GROW … INTO … BOW ECHOES WITH A RISK FOR DAMAGING WINDS AND LARGE HAIL …*

- August 10, 2020, 1300 *UTC*

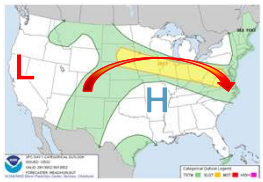


- **SPC text:** *TRENDS…SUGGEST… A BOW ECHO WITH RISK OF DAMAGING WINDS. WIDESPREAD WIND THREAT MAY ENSUE.*

33

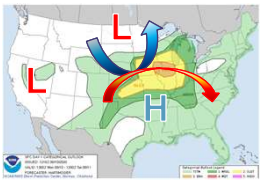
2012 Derecho vs. 2020 Derecho (Forecasts)

- June 29, 2012, 1300 *UTC*



- **SPC text:** *MULTIPLE STORMS … MAY DEVELOP AND GROW … INTO … BOW ECHOES WITH A RISK FOR DAMAGING WINDS AND LARGE HAIL …*

- August 10, 2020, 1300 *UTC*

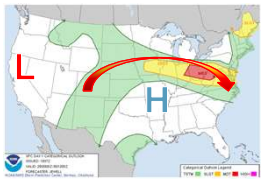


- **SPC text:** *TRENDS…SUGGEST… A BOW ECHO WITH RISK OF DAMAGING WINDS. WIDESPREAD WIND THREAT MAY ENSUE.*

34

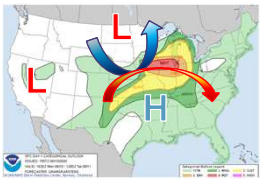
2012 Derecho vs. 2020 Derecho (Forecast Updates)

- June 29, 2012, 1630 *UTC*



- **SPC Text:** *MCS CONTINUES TO GROW… WINDS MEASURED AT 91 MPH. EXTREMELY UNSTABLE AIR MASS…THE SYSTEM MAY CONTINUE TO THE COAST.*

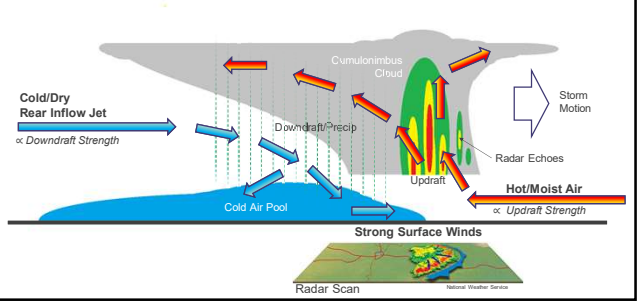
- August 10, 2020, 2000 *UTC*



- **SPC Text:** *POTENTIAL EXISTS FOR A DERECHO WITH INTENSE SEVERE GUSTS AND WIDESPREAD WIND DAMAGE ACROSS CENTRAL TO EASTERN IA, NORTHERN IL AND FAR SOUTHERN WI.*

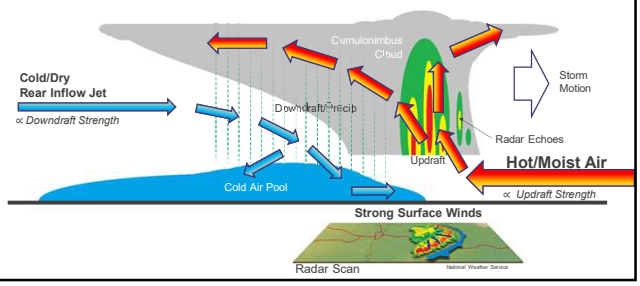
35

MCS Cross Section (2012 Derecho)



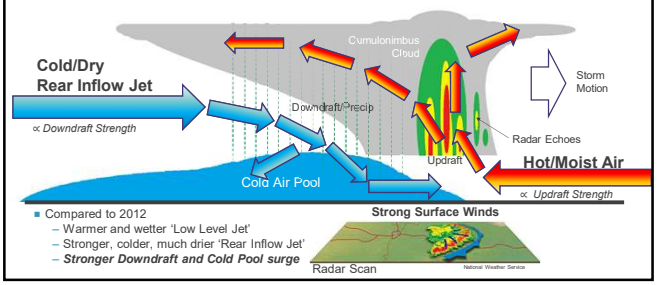
36

MCS Cross Section (2020 Derecho)



37

MCS Cross Section (2020 Derecho)



- Compared to 2012
  - Warmer and wetter 'Low Level Jet'
  - Stronger, colder, much drier 'Rear Inflow Jet'
  - ***Stronger Downdraft and Cold Pool surge***

38

Climate Change?

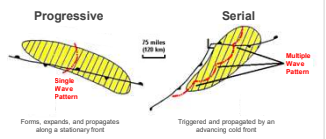
- Climate change impacts on derecho type weather is uncertain, however,
- Climate change could alter the propensity for strong continental high pressures which support *progressive derecho* formation.
  - Derechos typically occur during the high heat summer months. Climate change will increase the length of this season and therefore potentially increase total number of derechos each year.
  - The geography/scale of the high pressures may change with changing climate; however, this is also quite uncertain.
  - Less certainty on how climate change might affect wind velocity.

A Derecho is a '...widespread, convectively induced straight-line windstorm,...' with the following criteria:
- Wind damage extending more than 250 miles.
- Wind gusts of at least 58 mph along most of its length.
- Includes several, well-separated 75+ mph gusts.

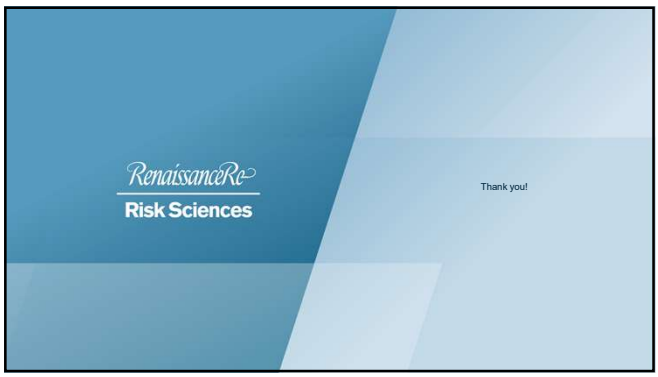
Derechos fall into two convective types:
- Progressive (Iowa Derecho)
- Serial

Derechos may contain tornados and hail, driving up event losses.

No official database of derechos exists (open to interpretation).



39



40