Parametric Insurance for Severe Convective Storms

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Arbol Inc.

Arbol Overview

Arbol has delivered rapid growth while maintaining profitability and sound underwriting

Access: 50% of clients would not have access to climate risk products without Arbol

Underwriting: Unique AI underwriter incorporating cutting edge climate science with systematic portfolio management techniques

Technology: Extensive data infrastructure, smart contracts and automated platforms to streamline insurance and derivative transactions

Capital: Underlying risk capacity to deliver competitive pricing to customers

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www.arbolmarket.com

$500M+
In dedicated risk capacity

$24M
Projected net revenue end of 2022

$200M+
Projected GWP (gross written premium) end of 2022

700+
Institutional clients

John Qiang ‘JQ’ Su

- Director of Insurance R&D, Arbol
- Previously at Swiss Re, Verisk and Amex
- Fintech/Insurtech investor since 2015
- FCAS 2008
- Ph.D. Princeton / Electrical Engineering

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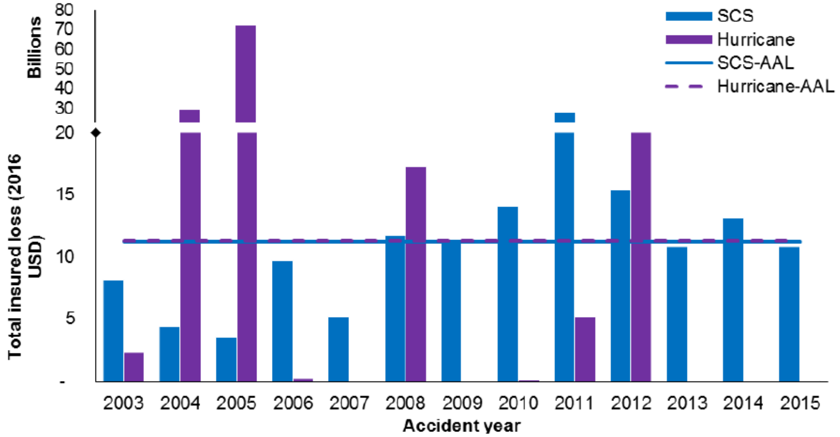
Severe Convective Storms: Three Main Perils

- Severe Convective Storms (SCS) cause avg. loss of $11.2B[1]
    - Hail: ~60%
    - Tornado: ~20%
    - Straight-line wind: ~20%



Source: Property Claim Services (PCS), a Verisk Analytics business

[1]Gunturi, P., & Tippett, M. (2017). Impact of ENSO on U.S. Tornado and Hail Frequencies (5 p.). Willis Re.

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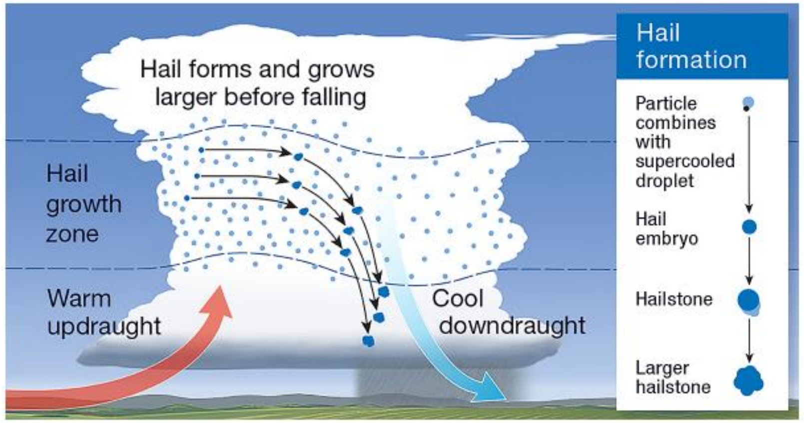
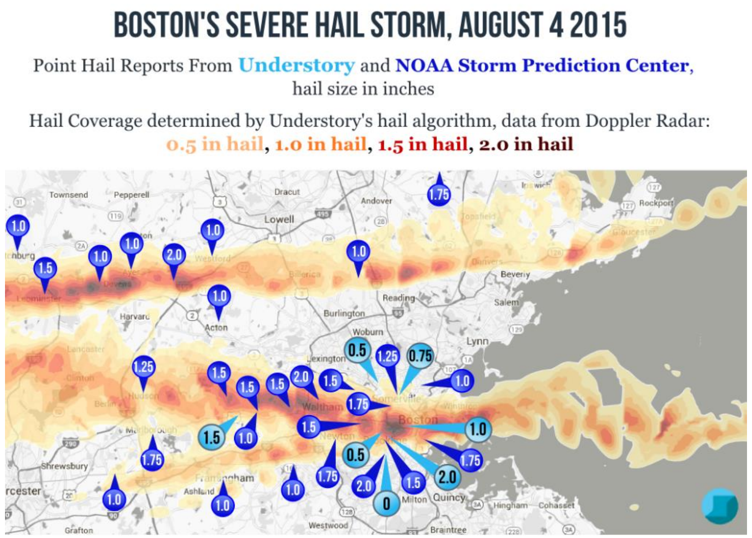
Hail

Hail Fundamentals

- Forms when water droplets pushed up into cold layers of atmosphere
- **Small-scale phenomenon**
  - Can be only a few spots in giant thunderstorm
- Care about both **location** and **size** of hail
  - Hail > 1 inch can cause major damage



Source: https://media.bom.gov.au/social/blog/1733/explainer-how-does-hail-form/



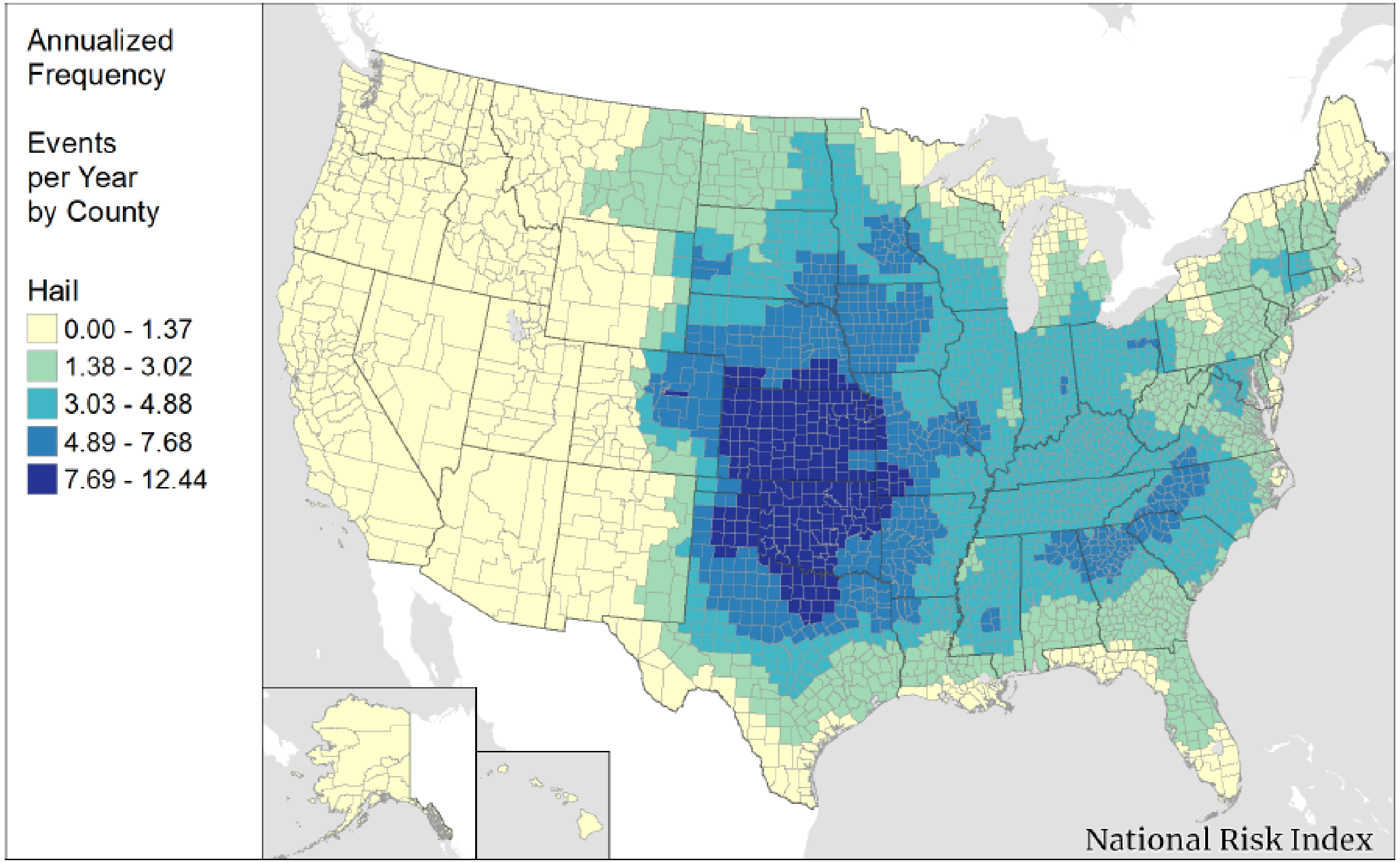
Source: https://www.boston.com/weather/

TORRO H-Scale for Hail Intensity

Scale	Intensity category	Typical hail diameter (mm)*	Probable kinetic energy $J\ m^{-2}$	Typical damage impacts
H0	Hard hail	5	0-20	No damage
H1	Potentially damaging	5-**15**	>20	Slight general damage to plants, crops
H2	Significant	10-**20**	>100	Significant damage to fruit, crops, vegetation
H3	Severe	20-**30**	>300	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	Severe	25-**40**	>500	Widespread glass damage, vehicle bodywork damage
H5	Destructive	30-**50**	>800	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	40-**60**		Bodywork of grounded aircraft dented, brick walls pitted
H7	Destructive	50-**75**		Severe roof damage, risk of serious injuries
H8	Destructive	60-**90**		(Severest recorded in the British Isles) Severe damage to aircraft bodywork
H9	Super Hailstorms	75-**100**		Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	Super Hailstorms	>100		Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: https://www.torro.org.uk/research/hail/hscale

Most Hail Occurs in Midwest

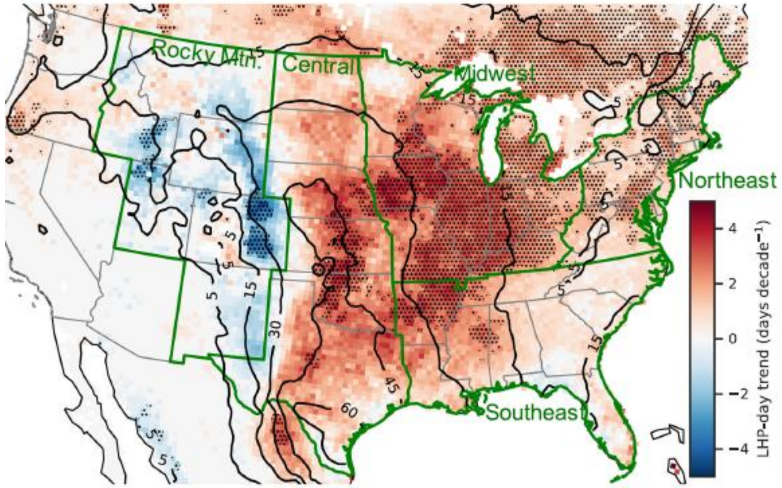


Source: https://www.fema.gov/flood-maps/products-tools/national-risk-index

Climate Change: More Frequent, Widespread Hail

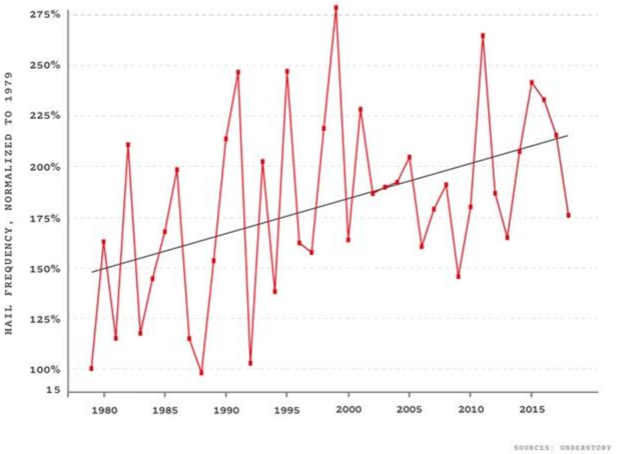
- Hail is (maybe) becoming more frequent
- Hail distribution is moving East

Spatial Trend in Hail Frequency



Source: https://www.nature.com/articles/s41612-019-0103-7

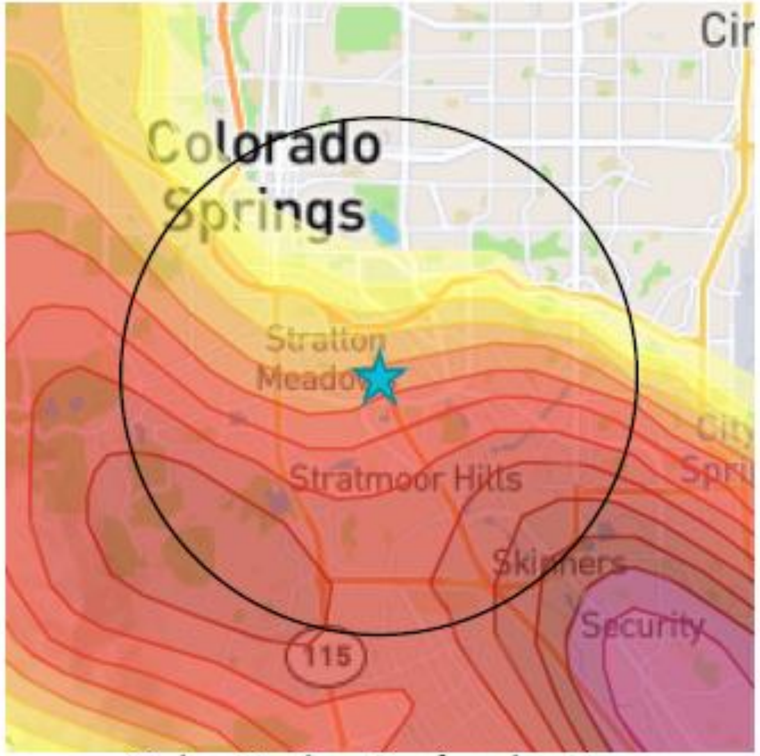
Hail Is Becoming More Frequent
in the Lower 48 States



Source: https://www.theatlantic.com/science/archive/2021/02/hail-its-americas-most-underrated-climate-risk/617979/

Need for Parametric Hail Product

- Hail damage on-par with tropical cyclones in most years, but underinsured
- Damage hard to quantify: e.g. hail accelerates weathering of roof
- Sensor or radar-based triggers can be transparent solution
- Target market: car dealerships, solar farms, etc.

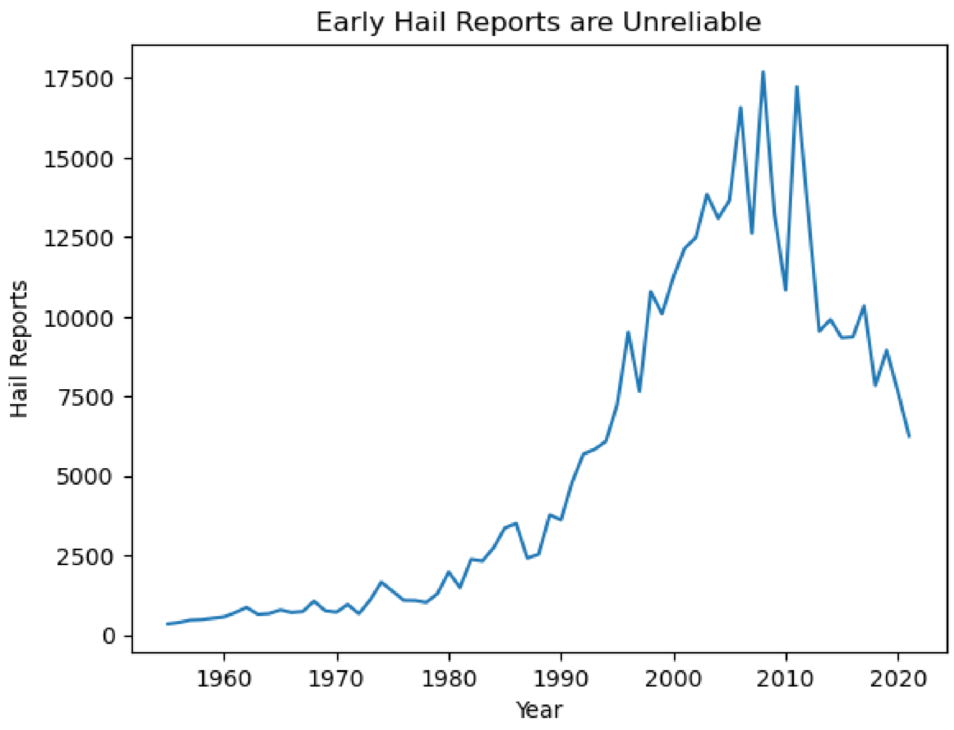


Circle ~ 3 mile radius from location.

Source: Canopy Weather

Observational Hail Data is Biased

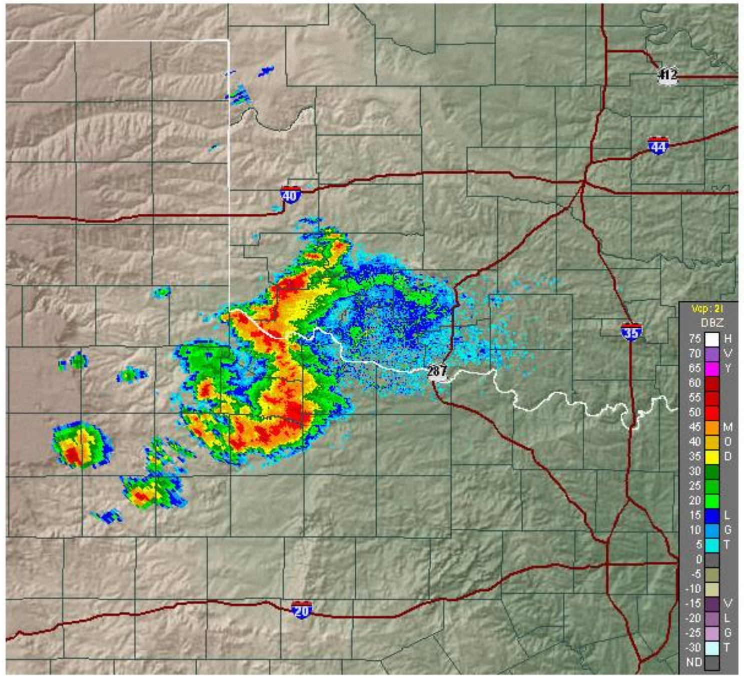
- Official data aggregated by NOAA is observational
  - Record back to 1950
- Many issues:
  - Reporting in past was harder = fewer reports
  - Fewer people in area = fewer reports
  - Hail size is biased down due to melting
  - Damage estimates are unreliable



Alternative Data: Radar

- Record back to 1998
- Big objects like hail have higher reflectivity
- MESH[1]: temp. weighted reflectivity predicts maximum expected size of hail
- Detects hail in the air, but not reality on the ground

Sample Composite Reflectivity Image

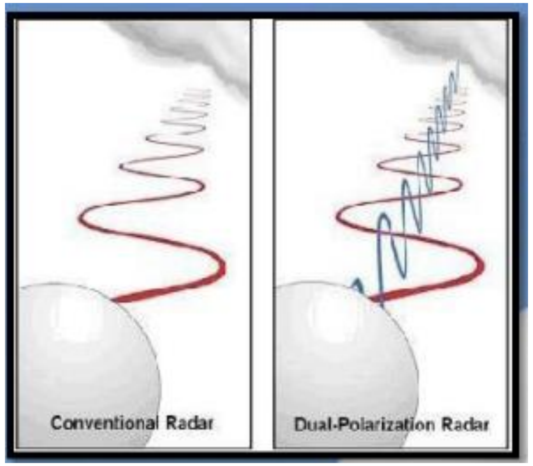


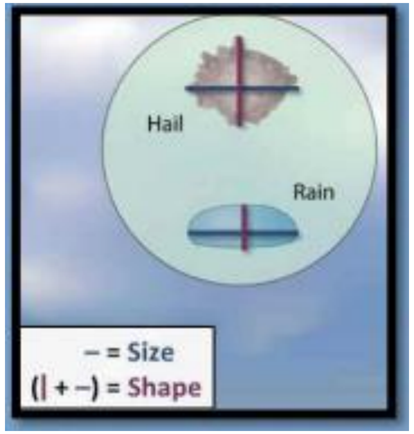
Source: https://www.weather.gov/jetstream/refl

[1]Witt, A. *et al*. An Enhanced Hail Detection Algorithm for the WSR-88D. *Weather and Forecasting* **13**, 286–303 (1998).

Recent Breakthrough: Dual-Polarization Radar

- NWS upgrades to dual-pol radar in 2013
- Detects shape by measure x- and y-coordinates of object
- Distinguish between hail/big rain/noise
  - E.g., rain is more “squished” due to drag



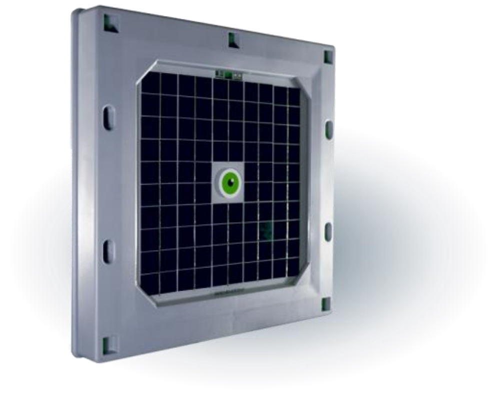


Source: https://www.weather.gov/media/lmk/soo/Dual_Pol_Overview.pdf

Parametric Trigger: Sensors

- Sensors provide reliable and fast ground-truth observations
- Several designs:
  - Sound based (big object = louder impact)
  - Force based (big object = more force of impact)
- Self-installation possible
- Little to no maintenance required (e.g., can be solar powered)

Source: HailSens

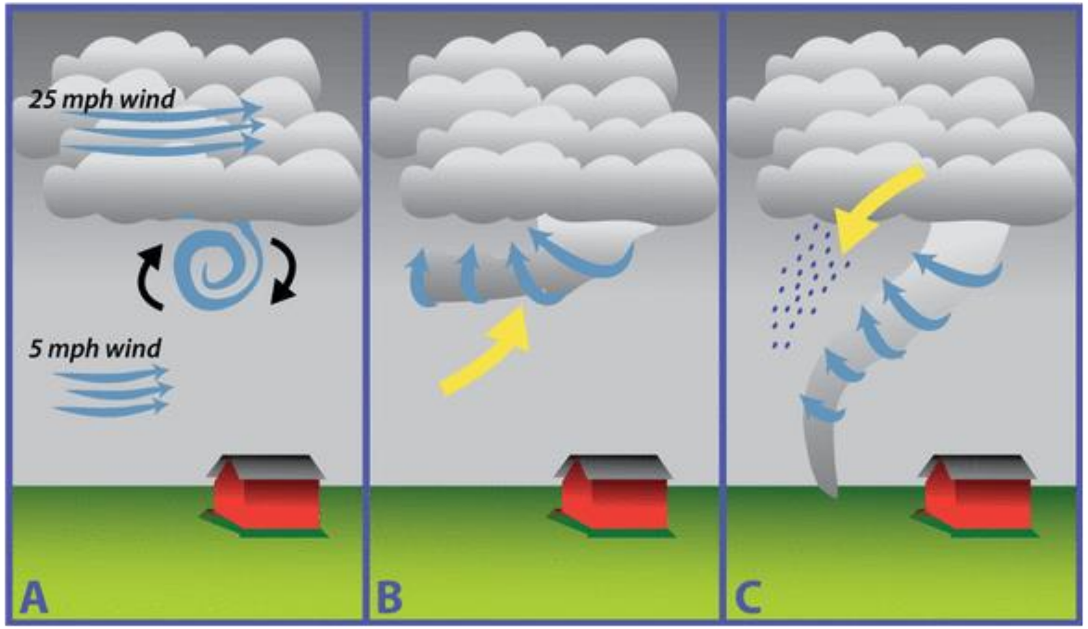


Source: Hailios

Tornadoes

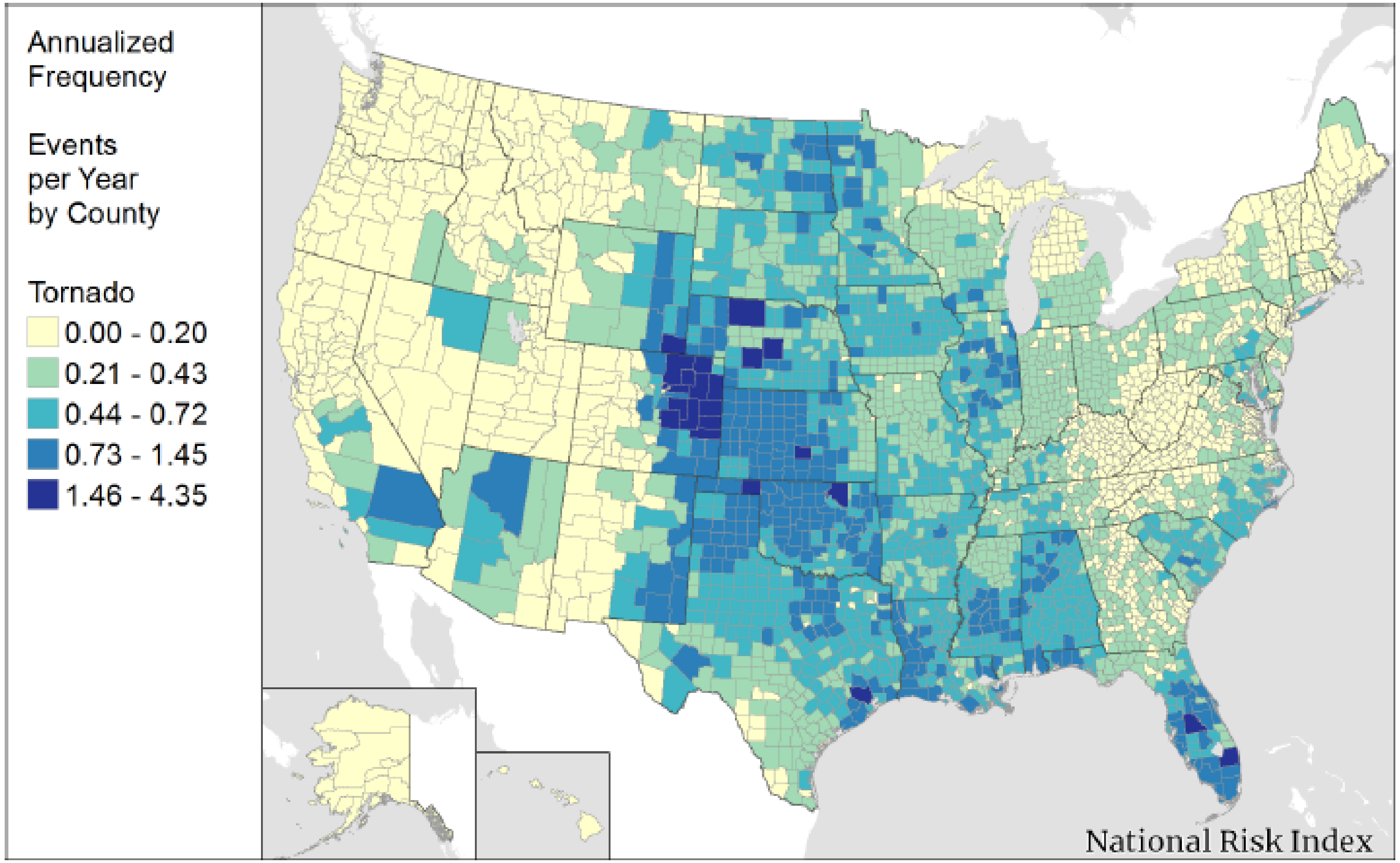
Tornado Fundamentals

- Environmental conditions:
  - Wind shear causes rotating wind parallel to the ground
  - Strong updraft flips the rotating column vertically
- Usually pretty small (~250 feet across) and don't travel very far (usually a few miles)
- Stronger tornados have longer path length – longest can reach 100s of miles
- Most occur in "Tornado alley" in middle of the country



Source: https://severeweathertornado.weebly.com/formation-of-a-tornado.html

Most Tornados Occur in Midwest and Southeast



Source: https://www.fema.gov/flood-maps/products-tools/national-risk-index

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Enhanced Fujita (EF) Scale

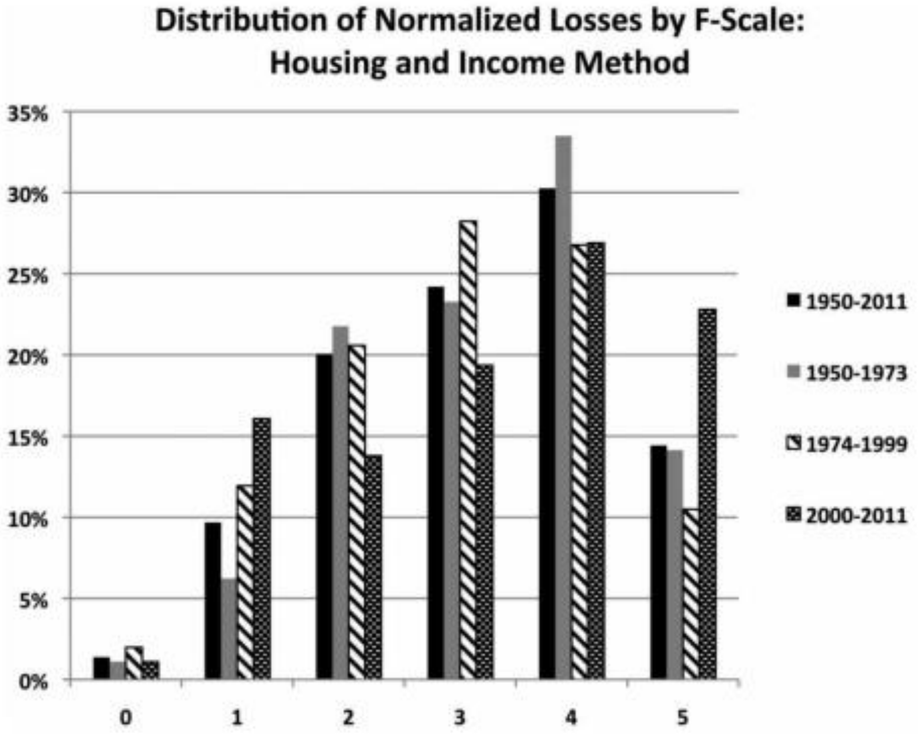
- Direct observations of tornado wind speeds unreliable
- EF scale of tornado intensity: 0-5, with 5 being the strongest
- EF scale is **damage based** but calibrated to **estimated** wind speed
  - 28 categories for how different buildings (two-story homes, mobile homes, etc.) were affected
  - Official post-hoc designation by NWS
- 80% of tornados are F0-F1; F4+ account for less that 1% of tornado events

F Scale	Character	Estimated winds	Description
Zero (F0)	Weak	40-72 mph	**Light Damage.** Some damage to chimneys; branches broken off trees, shallow-rooted trees uprooted, sign boards damaged.
One (F1)	Weak	73-112 mph	**Moderate damage.** Roof surfaces peeled off; mobile homes pushed foundations or overturned; moving autos pushed off road.
Two (F2)	Strong	113-157 mph	**Considerable damage.** Roofs torn from frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light objects become projectiles.
Three (F3)	Strong	158-206 mph	**Severe damage.** Roofs and some walls torn from well- constructed houses; trains overturned; most trees in forested area uprooted; heavy cars lifted and thrown.
Four (F4)	Violent	207-260 mph	**Devastating damage.** Well- constructed houses leveled; structures with weak foundation blown some distance; cars thrown; large missiles generated.
Five (F5)	Violent	260-318 mph	**Incredible damage.** Strong frame houses lifted off foundations, carried considerable distances, and disintegrated; auto-sized missiles airborne for several hundred feet or more; trees debarked.

Source: https://www.weather.gov/oun/efscale

History of Tornado Losses

- ~20 % of SCS avg. loss of $11.2B[1]
- F4 and F5 events cause nearly half of property damage and disproportionate life loss
- Destruction of homes can lead to **demand surge:** added basis risk



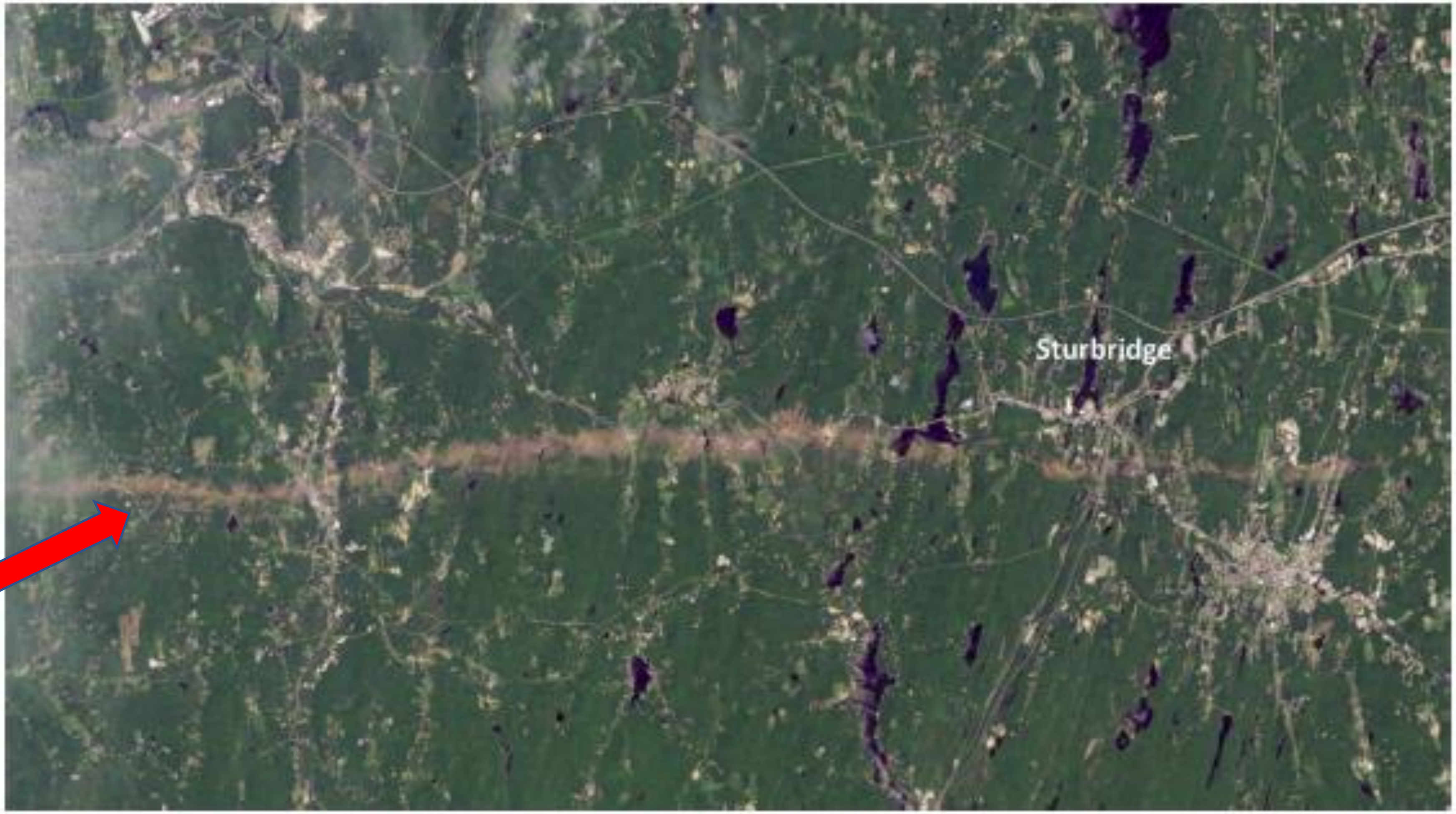
Source:
https://sciencepolicy.colorado.edu/admin/publication_files/2012.31.pdf

[1]Gunturi, P., & Tippett, M. (2017). Impact of ENSO on U.S. Tornado and Hail Frequencies (5 p.). Willis Re.

Tornado Data Sources and Biases

- Official data aggregated by NOAA
  - Record back to 1955
  - Track is uniform width line with start/end point
  - Later records are more reliable, but some biases persist
  - Can be used as (partial) parametric trigger
- Satellite:
  - More recent: e.g., GEOS-16 operational in 2016
  - Check if location looks different before/after a possible tornado
  - May not have great resolution and damage may not be evident
- Doppler radar: tornado vortex signature for real-time detection

Satellite Imagery from June 1, 2011 New England Tornado Outbreak



Tornado track
(EF3, 39 mi.)

Source: NASA (public domain)

Prevailing Modeling Methods

- FEMA: thicken and renormalize counts to agree with national total
- Remote sensing techniques[1]
  - Less critical to incorporate and technically simpler than hail
- Tornado path simulations[2] (similar to hurricanes)
- Bias correction using population density/urban development[3]

[1]Womble, J. Arn, Richard L. Wood, and Mohammad Ebrahim Mohammadi. "Multi-scale remote sensing of tornado effects." *Frontiers in built environment* 4 (2018): 66.

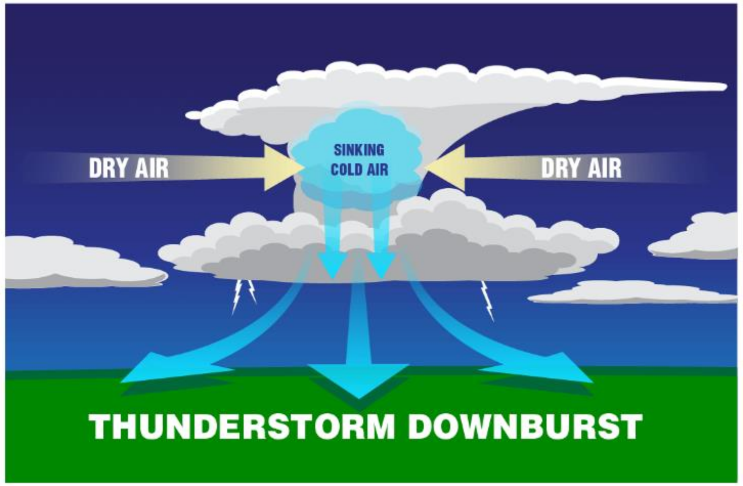
[2]Fan, Fanfu, and Weichiang Pang. "Stochastic track model for tornado risk assessment in the US." *Frontiers in built environment* 5 (2019): 37.

[3]Anderson, Christopher J., et al. "Population influences on tornado reports in the United States." *Weather and Forecasting* 22.3 (2007): 571-579.

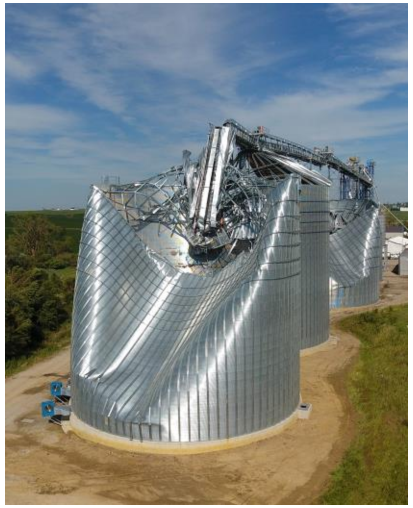
Straight-Line Wind

Straight-Line Wind Fundamentals

- Formed when strong downdraft pushes air in a straight line very fast
- Differentiated from tornado by looking at debris patterns
- Wind can go 100+ mph: can cause catastrophic damage
- “Derechos” can be hundreds of miles wide



Source: https://scijinks.gov/derechos/



Source: https://www.weather.gov/dmx/2020derecho

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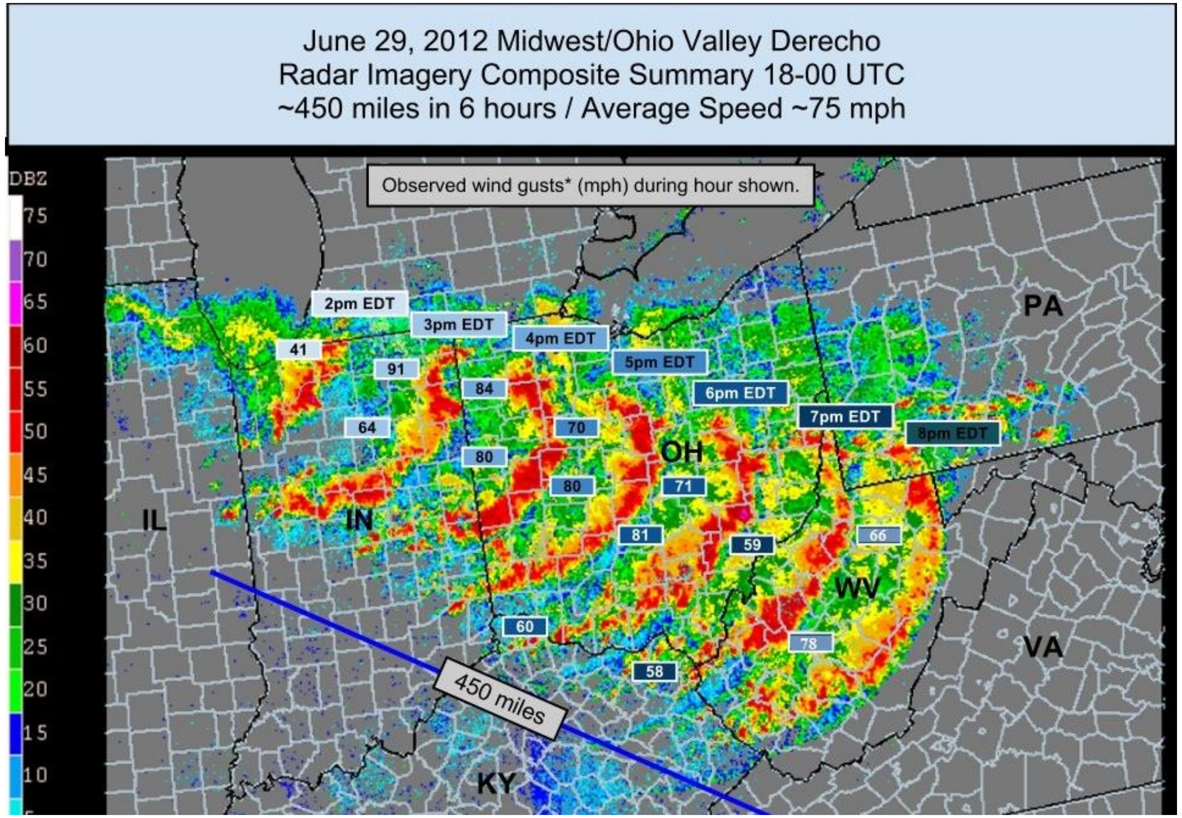
Straight-Line Wind are Difficult to Insure

- Straight-line winds cause widespread, unpredictable damage
- Wind gusts affected by local features like topography, cities, etc.
- Difficult to model/insure



Source: https://www.weather.gov/rlx/SVR062912

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Q&A

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