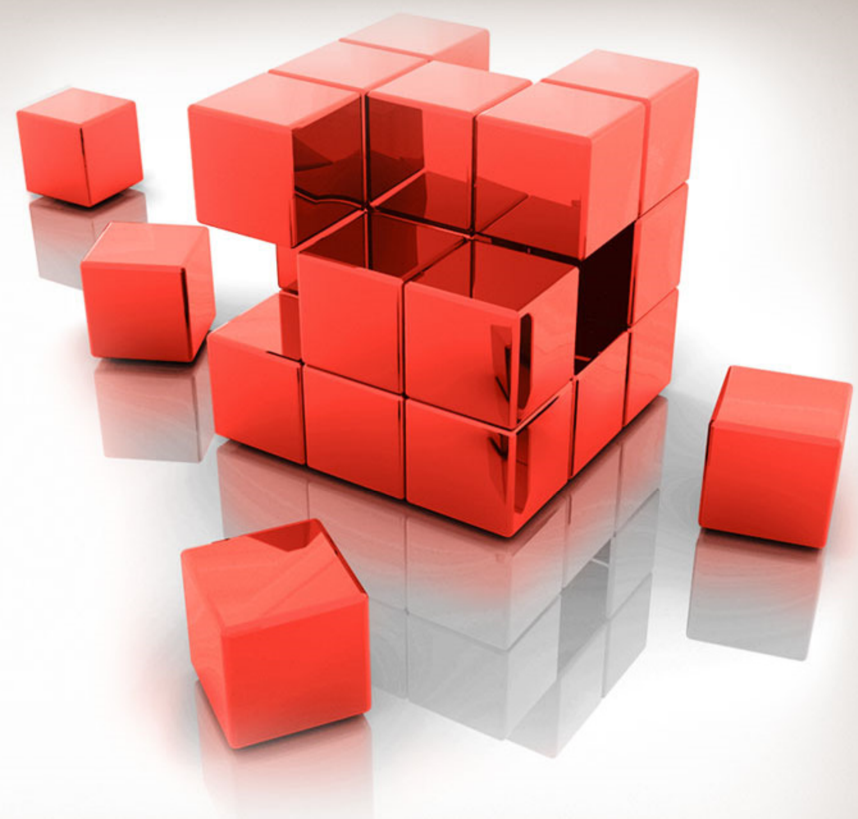
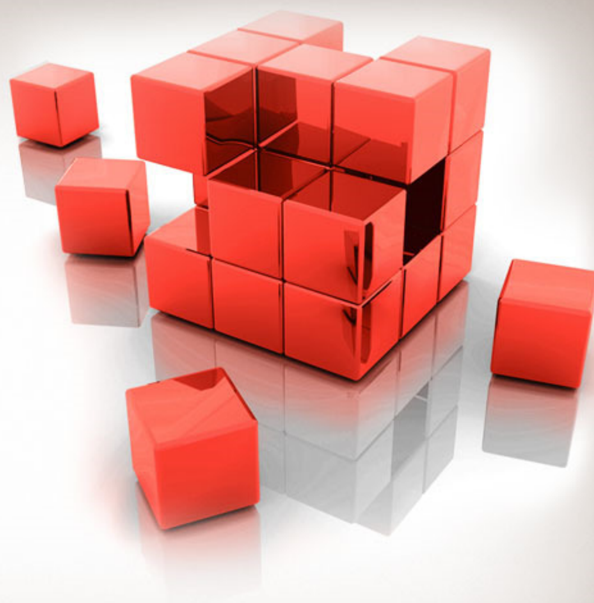


Setting Natural Catastrophe Reserves Using Weather Forensic Data



Weather Verification: Science

CAS Loss Reserve Seminar

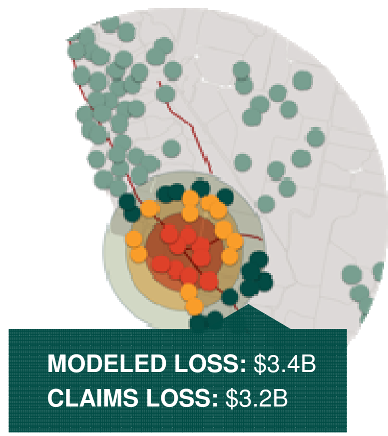
September 19, 2016

Curtis McDonald, Product Manager - Meteorologist

Types of Models

DETERMINISTIC

What could happen?



PROBABILISTIC

What if it happened?

FORENSIC

What did happen?

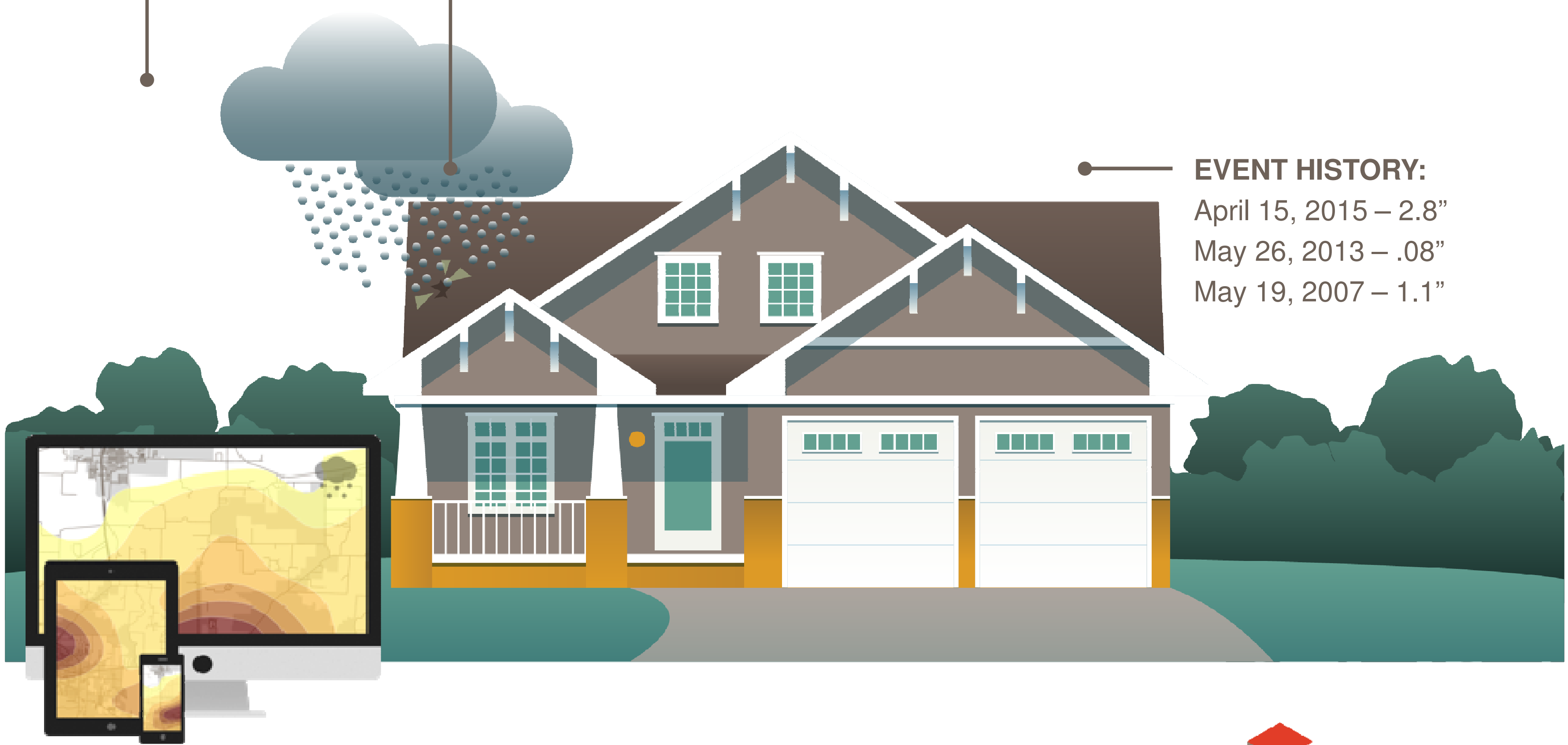
CoreLogic

Forensic Hail Verification Model

SIZE OF HAIL: 2.8”

EVENT DATE: April 15, 2015

EVENT HISTORY:
April 15, 2015 – 2.8”
May 26, 2013 – .08”
May 19, 2007 – 1.1”



CoreLogic

Forensic Wind Verification Model

WIND SPEED: 56mph

EVENT DATE: December 20, 2015

EVENT HISTORY:
Nov. 13, 2014 – 23mph

KH1

Severe Thunderstorm Losses

As at January 2014	Number of Events	Fatalities	Estimated Overall losses (US $bn)	Estimated Insured losses (US $bn)	10-year average Insured losses (US $bn)
Severe thunderstorm (1)	**802**	**1,606**	**180**	**120**	**12**
Winter events (2)	**122**	**760**	**25**	**15**	**1.5**
Flood (3)	**183**	**292**	**30**	**5. 5**	**0.55**
Earthquake & Geophysical	**31**	**5**	**1. 5**	**0.4**	**0.04**
Tropical Cyclone (4)	**38**	**1,786**	**320**	**170**	**17**
Wildfire, Heat, & Drought	**291**	**542**	**65**	**25**	**2.5**

Source: © 2015 Munich Re, NatCatSERVICE. As of January 2015.

(1) Includes hail, lightning, and tornado.
(2) Includes winter storm, winter damage, cold wave, and blizzards.
(3) Includes river flood, and flash flood. Exclude flood damage losses caused by tropical cyclone and hurricane.
(4) Includes flooding caused by hurricane, tropical cyclone. Includes loss information from National Flood Insurance Program.

CoreLogic

Slide 6

KH1 I'm unable to edit this table but suggest the following edits: Change the far left column heading to read "As of January 2014" However, are you able to get data from 2015 instead to make it more current? The titles in all of the column headings should begin with capital letters, expect for prepositions like "of" and "the"

Kelly, Helena, 9/8/2016

Hail Verification Technology

1960

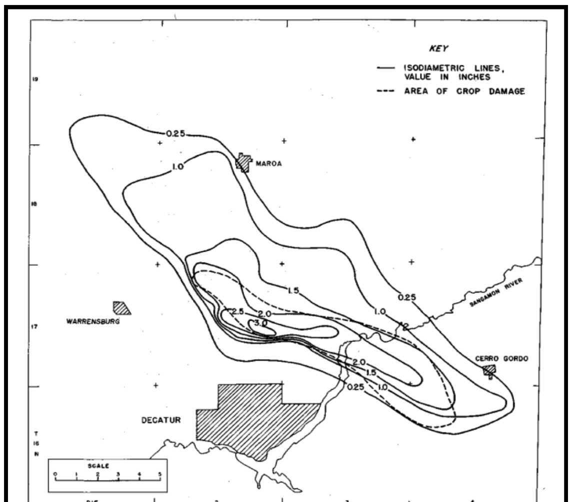
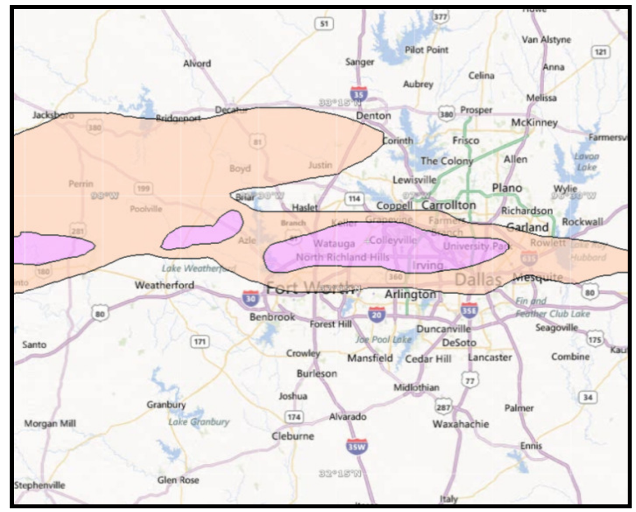


FIG. 6 DIAMETERS OF LARGEST OBSERVED STONE SIZES

- Hand-drawn maps
- Based on meteorologist’s interpretation of radar & human observations
- Took 24+ hours to produce
- Subjective and inconsistent

2009



- Hand-drawn maps
- Based on meteorologist’s interpretation of radar & human observations
- Took 24+ hours to produce
- Subjective and inconsistent
- Color!

CoreLogic

Why No Advancement in 50 Years?

Always the same two sources of hail data:

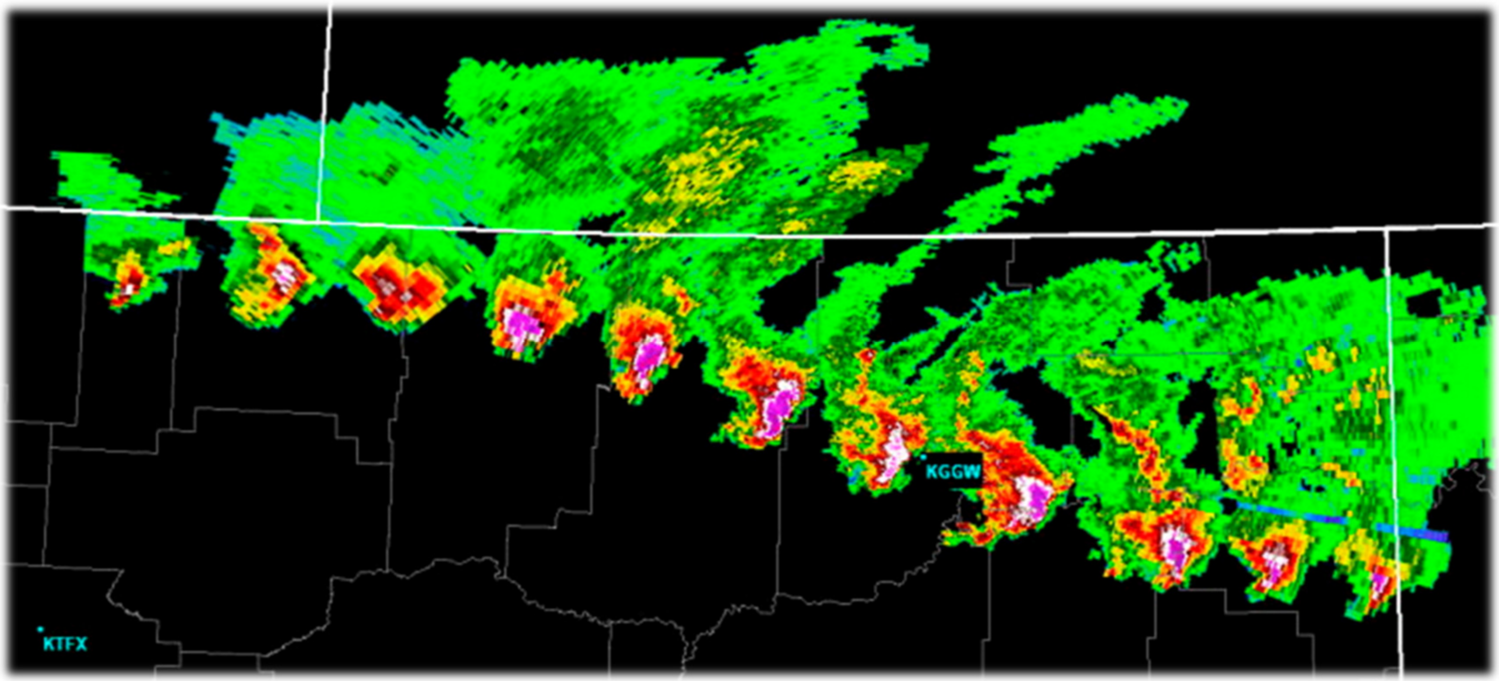
Radar

Human Observations

CoreLogic

Radar Limitation #1

- Radar only measures storm every 3-5 minutes
- Hail core can move significantly in 5 minutes
- Result is gaps in storm paths ("footprints")



CoreLogic

Solution to Radar Limitation #1

- In 50 years, no meteorological solution
- Phased Array Radar (faster scans), very expensive and many years away
- Recent changes to the radar scans can shorten the gap some, producing data every 2-3 min.

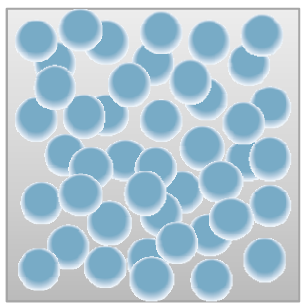
Unconventional Approach to Problem:

- Used techniques from graphic design
- Developed sophisticated and proprietary morphing algorithm
- Morphs one radar image into next
- Can determine storm location & structure every 3 seconds

Radar Limitation #2

- Radar now works great for location, but…
- Doesn't measure hail size
- Measures reflectivity
- Cross-sectional area of whatever radar beam hits (hail, rain drops, bugs, etc.)

Lots of tiny hailstones



One large hailstone

- On radar, many small hailstones may look the same as a few large ones

CoreLogic

Humans Can Measure Hail Size…

...but it’s not easy!

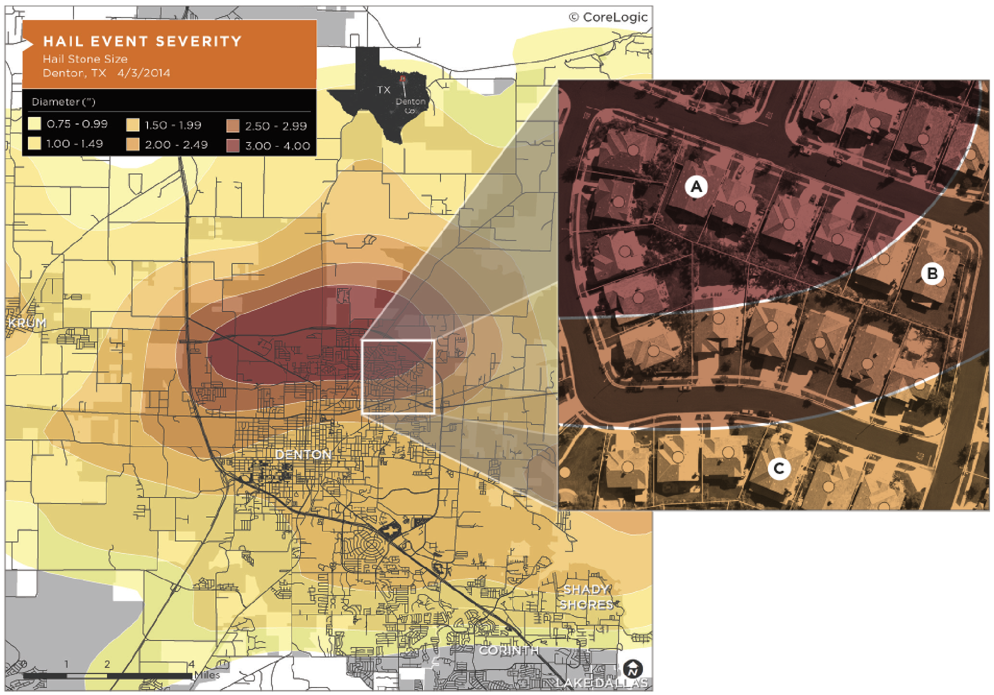
Problems with Public Storm Reports

- Anyone can call in a hail report
- People tend to exaggerate weather reports and stories
- Some reports are ambiguous
- False reports

Examples of Official NWS Hail Reports:

- 4.00” Dallas, TX
- 1.75” Clayton, AL (actually Clanton, AL, 100 miles away)
- 0.75” Cherry size hail, Oakland, IA
- 1.00” Cherry size hail, Ripton, VT

CoreLogic's Forensic Hail Data



- Artificial intelligence algorithm
- Replicates thinking process of human meteorologists creating hand-drawn maps
- Objectively compares each report with radar data, filters out bad ones
- Faster, more objective, MORE CONSISTENT than hand-drawn maps

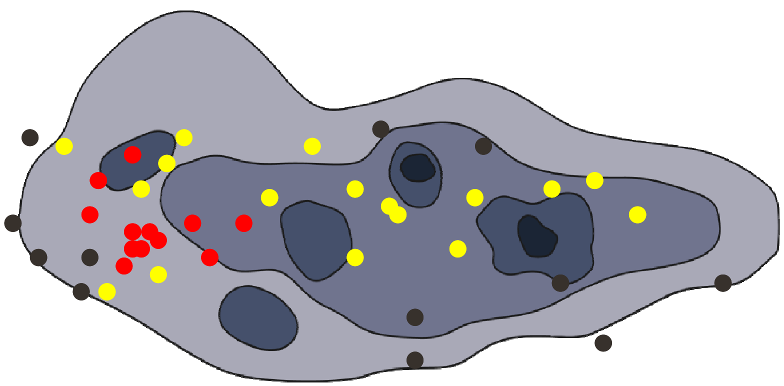
Why CoreLogic Developed Forensic Hail Data

- Insurance and construction industries needs accurate weather verification
- Competitors use methods intended for weather forecasting and public safety
  - Example: Hail Detection Algorithm (HDA)
    - Developed by National Severe Storms Laboratory (NSSL) to improve storm warnings
    - Was designed to exceed observed hail sizes 75% of the time (worst-case scenario)
    - Observed hail size error is 1.59”[1]
    - Is not a feasible option for use as a hail verification tool[2]
    - Should not be relied upon for accurate determination of severity or damage[3]
  - Why do competitors use inappropriate tools?
    - It allows them to avoid R&D spend

[1] Ortega et al 2008
[2] Wilson et al 2009
[3] Institute for Business and Home Safety (IBHS) study

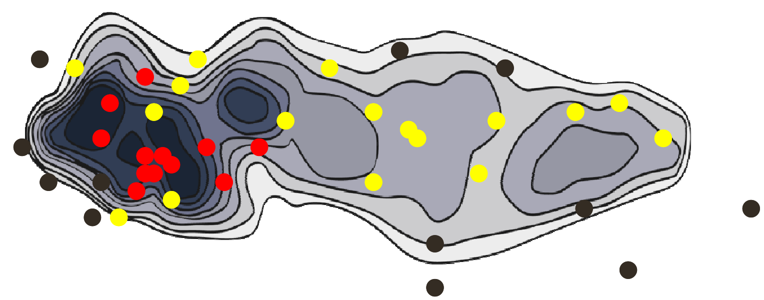
Forensic Hail Data Comparison

Competitive
HDA-Based Hail Data

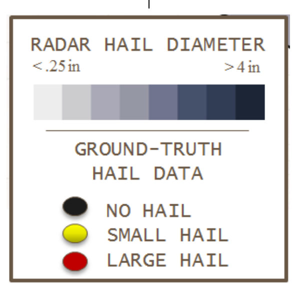


Not Appropriate for Insurance, Contractors, Engineers, etc.

CoreLogic
Hail Verification Data



Recommended for Insurance, Contractors, Engineers, etc.



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Automated Hail Data / Algorithms

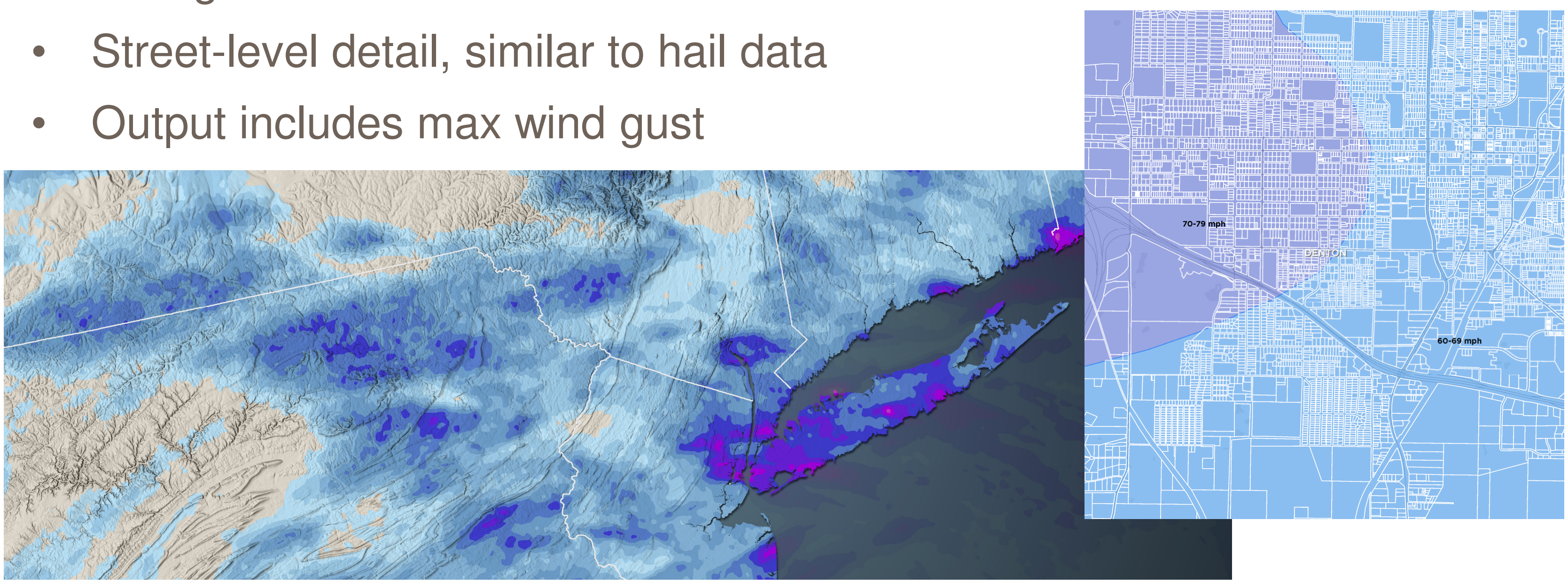
Key Differences	Hail Verification Science from CoreLogic	HDA-based Data
Primary Usage	Created for accurate hail size and location verification	Weather forecasting and public safety warning
Model Inputs	Interprets the best available weather and radar data in conjunction with on-the-ground observations of hail 3-dimensional storm models, hail verification algorithms, and artificial intelligence models	Weather radar data
Claim Verification & Accuracy	4x better at indicating areas where hail damage to property is likely[1] Consistently compares well to actual claims activity	Has systematic errors of 1.59" [2] Does not match well with ground truth data [3] Should not be relied upon for accurate determination of severity or damage [4] Should not be used as a hail verification tool [5]

CoreLogic

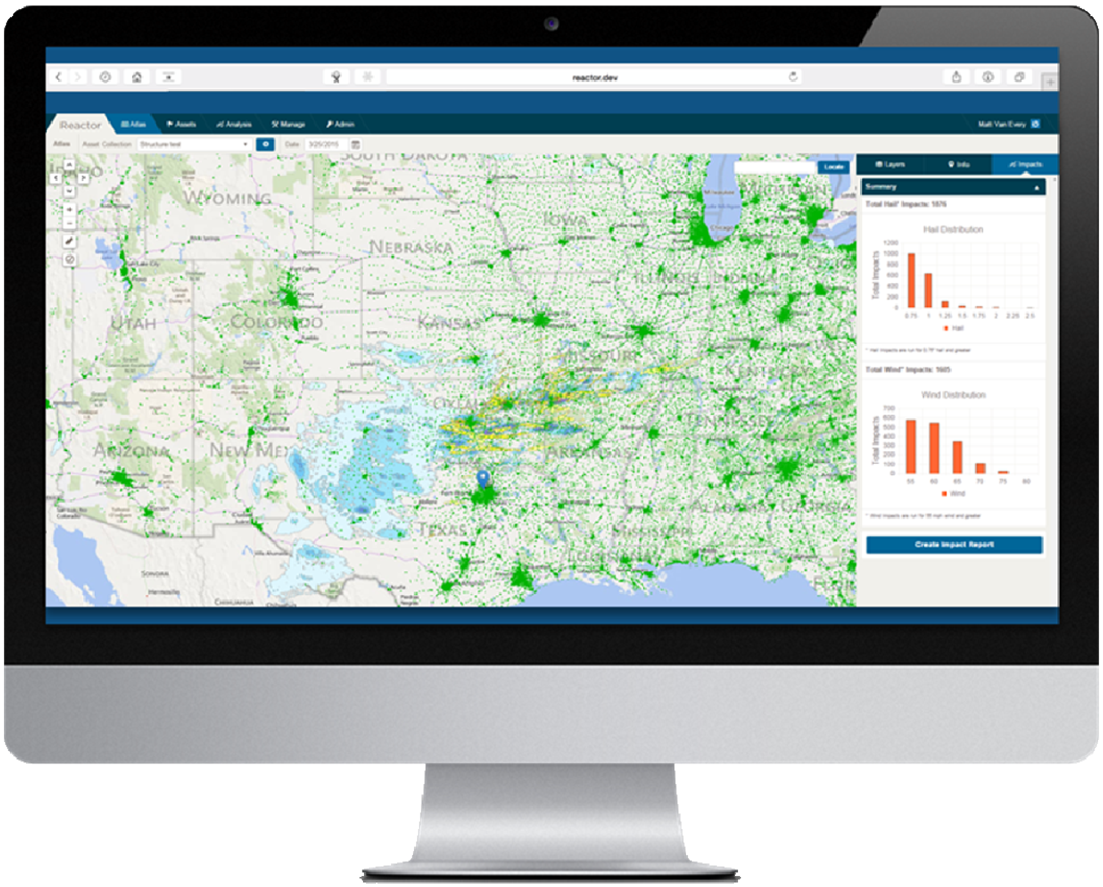
Weather Verification Data & Other Perils

Forensic Wind Data

- First ever high-resolution verification system for all types of severe wind (including thunderstorms)
- Uses morphing, physics, 3-D storm modeling, and artificial intelligence to overcome radar limitations
- Street-level detail, similar to hail data
- Output includes max wind gust



Weather Verification Data & Claim Management

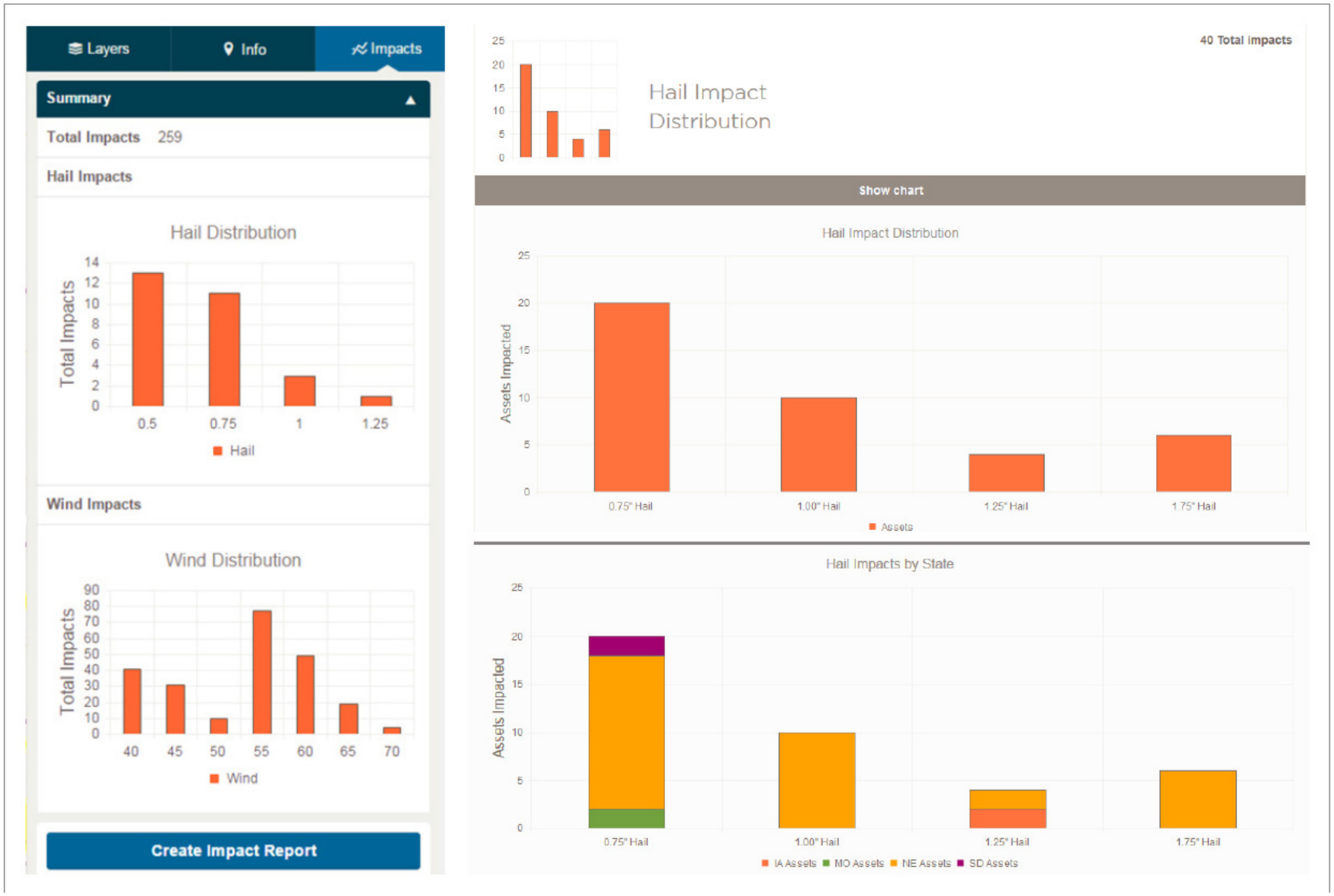


Reactor™

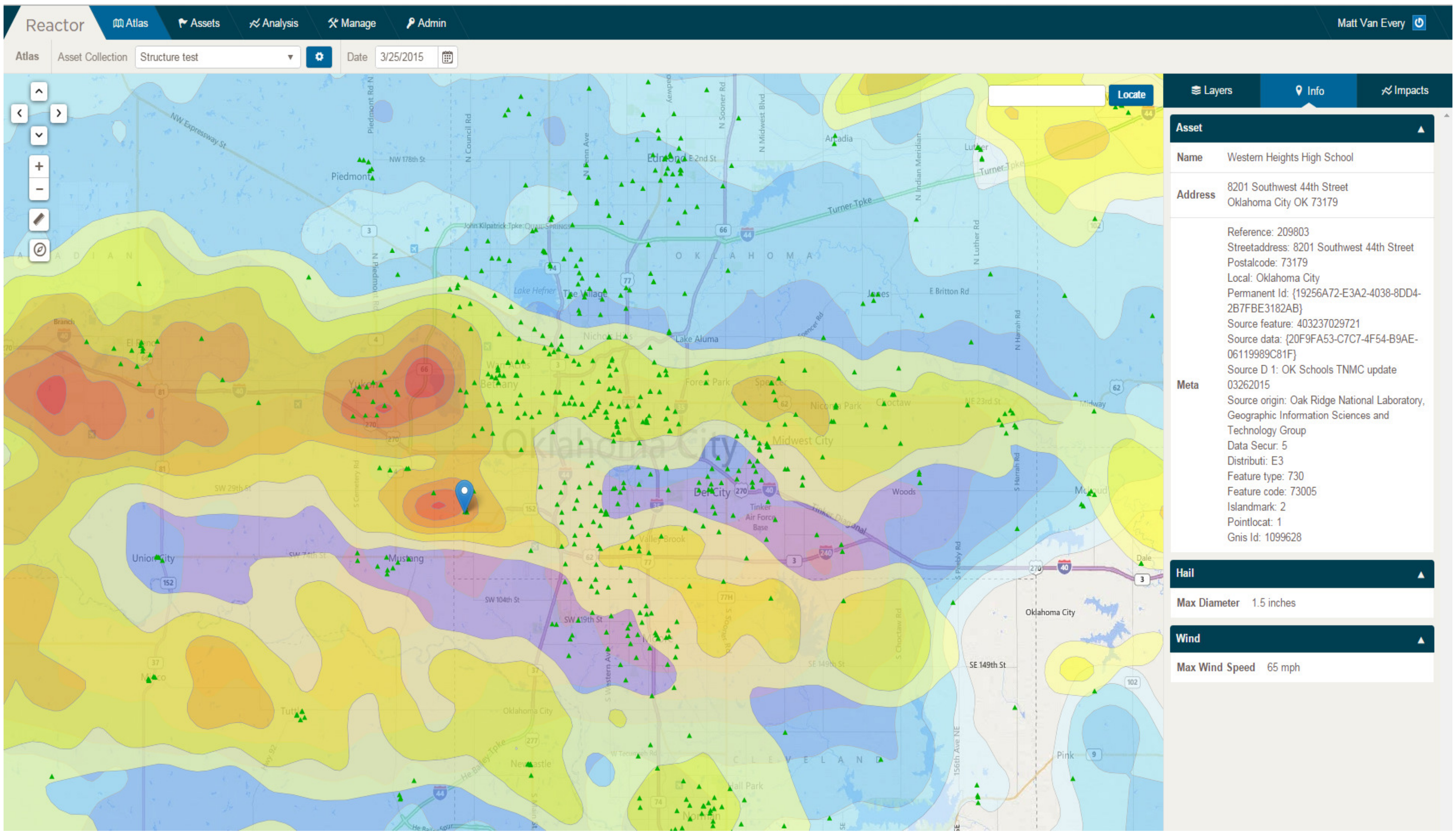
Web-based, easy to use platform that combines weather peril data with client supplied policies and assets to get quick needed answers following hail and wind events nationwide.

CoreLogic

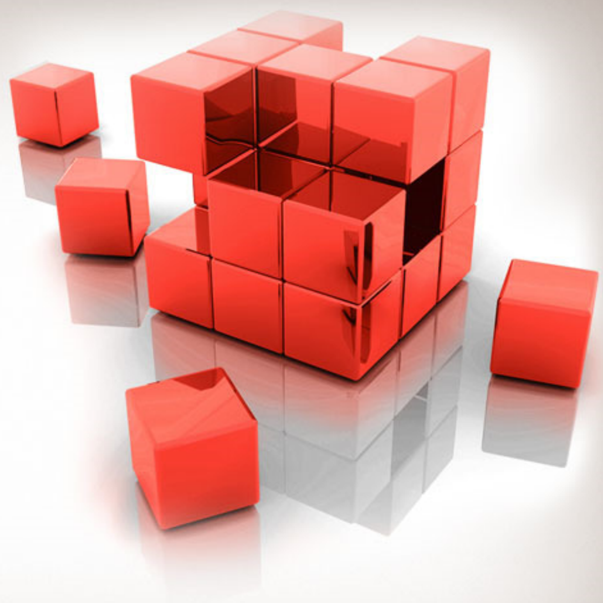
Weather Verification Data & Claim Management



Weather Verification Data & Claim Management



CoreLogic



Estimating Catastrophe Claims

CAS Loss Reserve Seminar

September 19, 2016

Howard A. Kunst, Chief Actuary - FCAS MAAA

Agenda

- Historical uses of model results in post-event catastrophe reserving
  - Development over time
  - Simulation
- How to use “real time” weather forensic data

Historical methodologies

- Traditional chain ladder methods
  - Compare claim count / payments / incurred estimates to prior events of similar characteristics
  - Timing – may need weeks of data before any reasonable estimates can be made

Claim Count & Paid / Incurred Development

- % incurred / reported at any point (weeks?)

Claim counts	Weeks after the event:												
	1	2	3	4	5	6	7	8	9	10	11	12	. . .	Ultimate
Storm 1	319	405	517	534	689	723	740	749	749	801	801	827		861
Storm 2	241	256	412	440	582	582	625	625	632	682	682	682		710
Storm 3	78	120	170	188	215	230	269	269	269	272	272	290		299
Storm 4	249	325	483	574	581	589	619	664	702	717	717	717		755
Storm 5	198	383	383	451	520	595	595	595	622	629	629	643		684
Storm 6	217	322	377	454	580	601	601	615	615	643	671	671		699
Storm 7	88	185	345	371	407	407	438	438	458	464	479	484		515
Storm 8	150	365	451	458	566	616	623	659	659	659	695	695		716
Storm 9	120	161	244	355	355	364	383	415	415	415	424	443		461

% reported	Weeks after the event:												
	1	2	3	4	5	6	7	8	9	10	11	12	. . .
Storm 1	0.3705	0.4704	0.6005	0.6202	0.8002	0.8397	0.8595	0.8699	0.8699	0.9303	0.9303	0.9605	
Storm 2	0.3394	0.3606	0.5803	0.6197	0.8197	0.8197	0.8803	0.8803	0.8901	0.9606	0.9606	0.9606	
Storm 3	0.2609	0.4013	0.5686	0.6288	0.7191	0.7692	0.8997	0.8997	0.8997	0.9097	0.9097	0.9699	
Storm 4	0.3298	0.4305	0.6397	0.7603	0.7695	0.7801	0.8199	0.8795	0.9298	0.9497	0.9497	0.9497	
Storm 5	0.2895	0.5599	0.5599	0.6594	0.7602	0.8699	0.8699	0.8699	0.9094	0.9196	0.9196	0.9401	
Storm 6	0.3104	0.4607	0.5393	0.6495	0.8298	0.8598	0.8598	0.8798	0.8798	0.9199	0.9599	0.9599	
Storm 7	0.1709	0.3592	0.6699	0.7204	0.7903	0.7903	0.8505	0.8505	0.8893	0.9010	0.9301	0.9398	
Storm 8	0.2095	0.5098	0.6299	0.6397	0.7905	0.8603	0.8701	0.9204	0.9204	0.9204	0.9707	0.9707	
Storm 9	0.2603	0.3492	0.5293	0.7701	0.7701	0.7896	0.8308	0.9002	0.9002	0.9002	0.9197	0.9610	
avg reported	0.2824	0.4335	0.5908	0.6742	0.7833	0.8199	0.8600	0.8833	0.8987	0.9235	0.9389	0.9569	

Claim Count & Paid / Incurred Development

- % incurred / reported at any point (weeks?)

Tot $ reported	Weeks after the event:													
	1	2	3	4	5	6	7	8	9	10	11	12		Ultimate
Storm 1	602,680	941,633	1,660,398	1,830,457	2,089,392	2,444,724	2,460,831	2,603,690	2,719,563	2,723,230	2,805,462	2,810,412		2,964,416
Storm 2	2,021,572	2,129,624	2,697,570	3,307,689	4,463,752	4,521,700	4,789,548	5,133,528	5,152,716	5,151,732	5,289,548	5,305,644		5,597,349
Storm 3	1,201,288	1,354,916	1,662,343	2,512,640	2,586,720	2,665,820	3,066,800	3,109,995	3,140,991	3,202,835	3,241,628	3,239,312		3,448,305
Storm 4	719,964	1,817,600	2,652,932	3,574,794	3,793,712	4,700,652	4,984,947	5,055,897	5,063,465	5,444,405	5,432,790	5,448,950		5,700,262
Storm 5	828,368	1,331,535	2,164,140	2,657,750	2,689,250	2,814,626	3,152,590	3,220,070	3,346,635	3,335,424	3,370,269	3,433,608		3,669,995
Storm 6	1,006,622	1,887,347	2,135,163	2,643,840	2,868,167	3,109,810	3,382,995	3,638,253	3,627,390	3,639,105	3,827,946	3,864,000		3,987,291
Storm 7	2,773,221	4,651,581	5,830,332	8,178,720	8,434,272	9,137,670	9,146,220	10,267,472	10,318,032	10,386,288	10,903,200	11,160,766		11,526,575
Storm 8	2,516,395	3,756,626	5,020,525	5,831,259	6,759,032	7,596,240	7,735,120	8,208,552	8,193,625	8,723,475	8,698,815	8,740,600		9,241,057
Storm 9	794,625	1,863,720	2,673,594	3,113,964	3,163,608	3,307,302	3,614,394	3,651,618	4,025,034	4,058,715	4,108,751	4,294,724		4,501,600

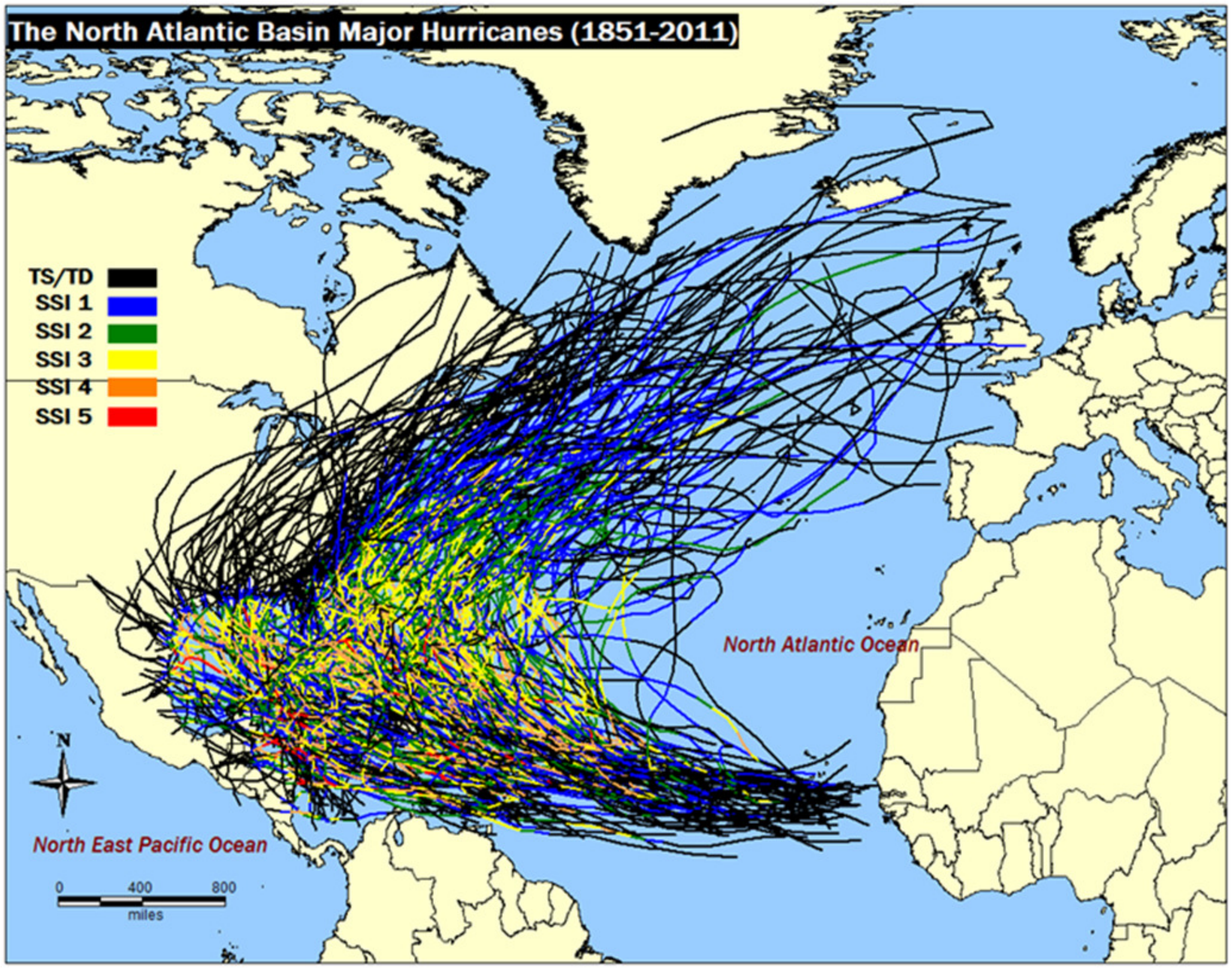
% reported $'s	Weeks after the event:											
	1	2	3	4	5	6	7	8	9	10	11	12
Storm 1	20.33%	31.76%	56.01%	61.75%	70.48%	82.47%	83.01%	87.83%	91.74%	91.86%	94.64%	94.80%
Storm 2	36.12%	38.05%	48.19%	59.09%	79.75%	80.78%	85.57%	91.71%	92.06%	92.04%	94.50%	94.79%
Storm 3	34.84%	39.29%	48.21%	72.87%	75.01%	77.31%	88.94%	90.19%	91.09%	92.88%	94.01%	93.94%
Storm 4	12.63%	31.89%	46.54%	62.71%	66.55%	82.46%	87.45%	88.70%	88.83%	95.51%	95.31%	95.59%
Storm 5	22.57%	36.28%	58.97%	72.42%	73.28%	76.69%	85.90%	87.74%	91.19%	90.88%	91.83%	93.56%
Storm 6	25.25%	47.33%	53.55%	66.31%	71.93%	77.99%	84.84%	91.25%	90.97%	91.27%	96.00%	96.91%
Storm 7	24.06%	40.36%	50.58%	70.96%	73.17%	79.27%	79.35%	89.08%	89.52%	90.11%	94.59%	96.83%
Storm 8	27.23%	40.65%	54.33%	63.10%	73.14%	82.20%	83.70%	88.83%	88.67%	94.40%	94.13%	94.58%
Storm 9	17.65%	41.40%	59.39%	69.17%	70.28%	73.47%	80.29%	81.12%	89.41%	90.16%	91.27%	95.40%
Avg % reported	24.5%	38.6%	52.9%	66.5%	72.6%	79.2%	84.3%	88.5%	90.4%	92.1%	94.0%	95.2%

CoreLogic

Historical Methodologies

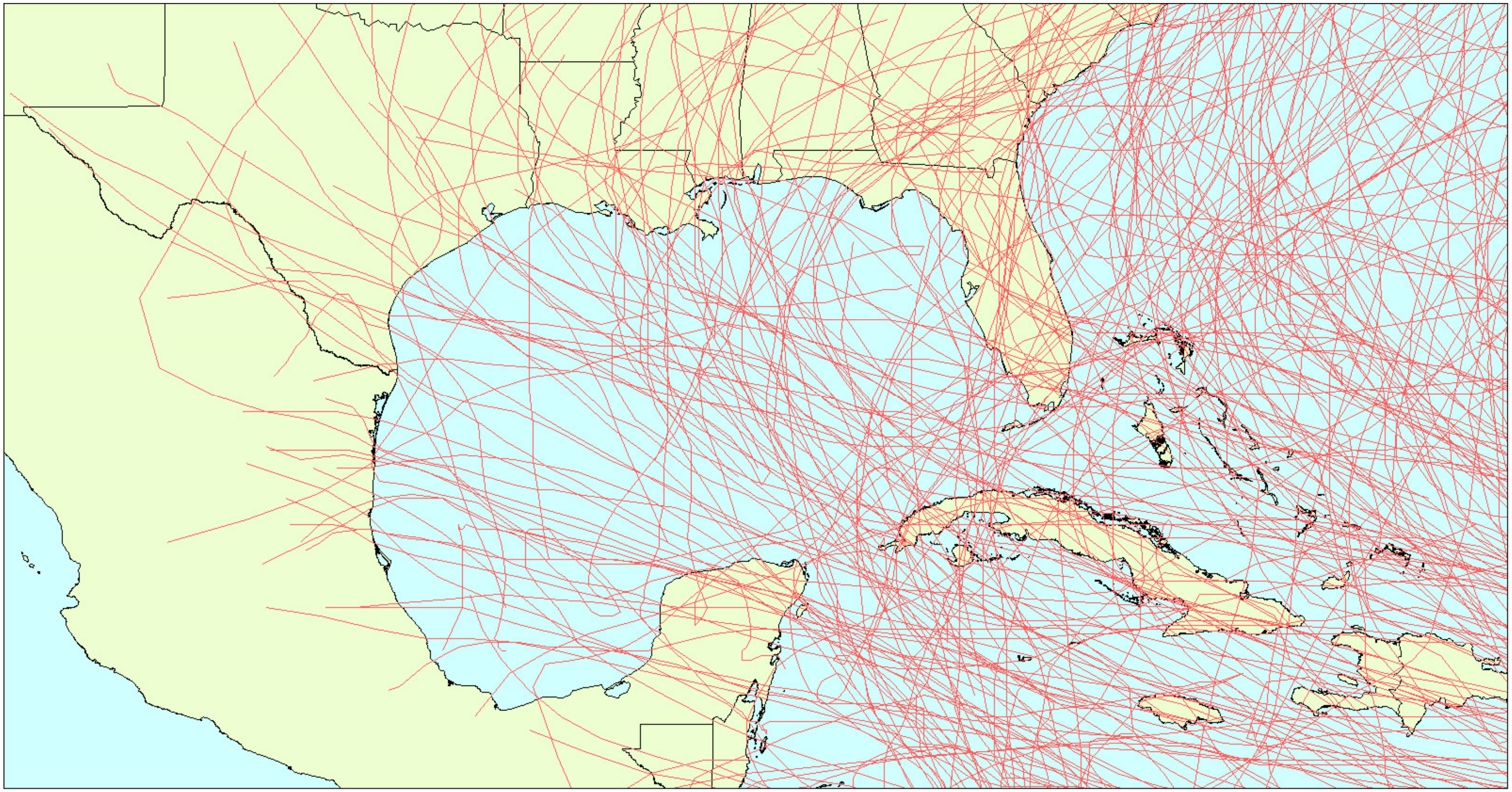
- High severity events have used simulation
  - Modeling company will review all of the events within their hazard event sets and determine which one is "closest"
  - Will then run simulation model with portfolio information
  - Produces a starting point – actual event will rarely be exactly like simulated event
  - Previously used for earthquake and hurricane events

Spaghetti Map of Hurricane Paths



KH2

Spaghetti Map of Hurricane Paths



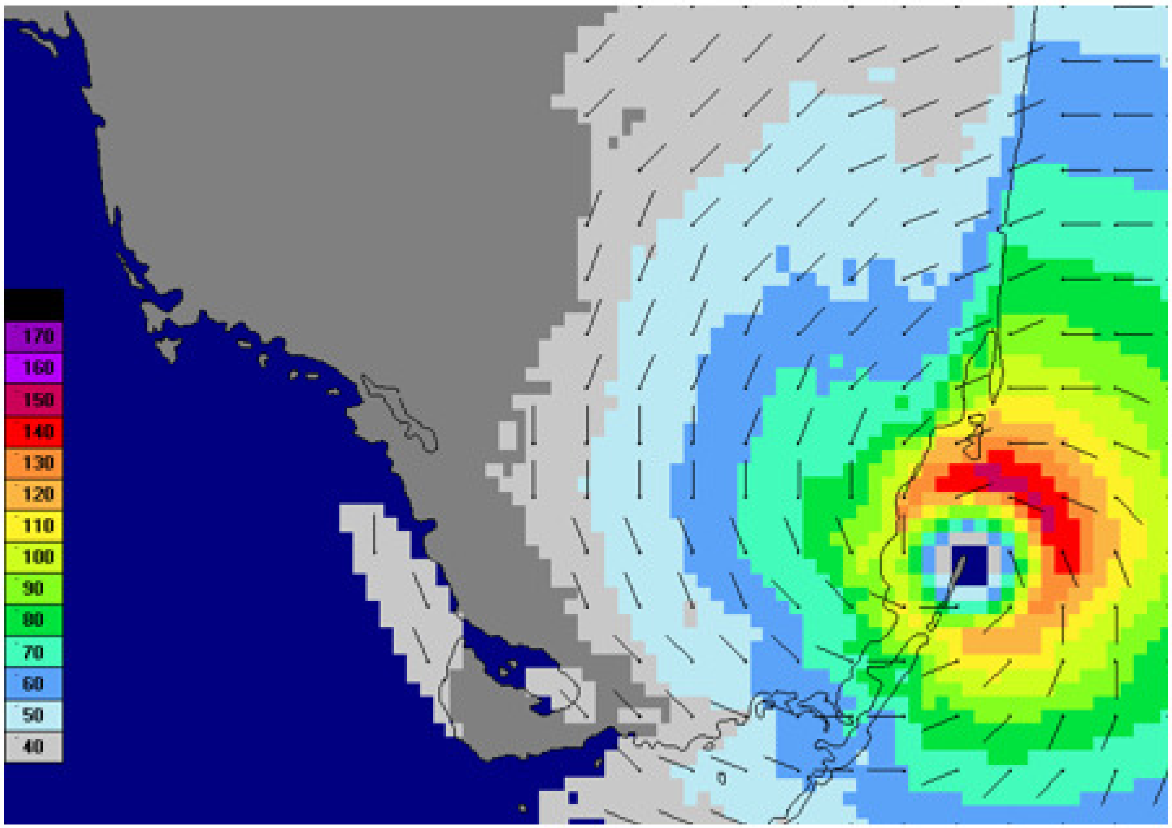
Slide 29

KH2 Consider adding a legend to this hurricane path map, as you did on the previous hurricane path map.
Kelly, Helena, 9/8/2016

Example of Wind Field at Landfall

Andrew (1992)

KH3



CoreLogic

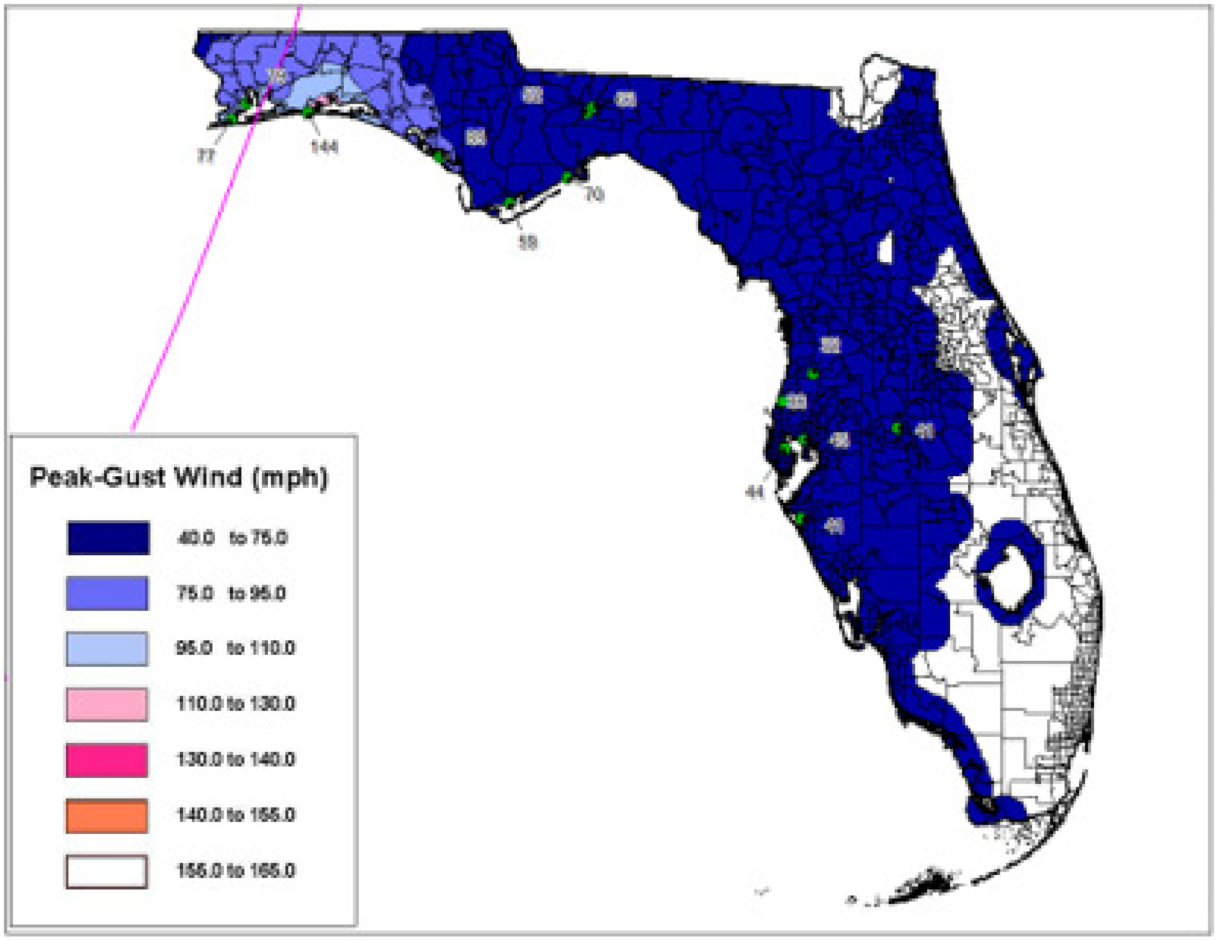
Slide 30

KH3 Title this "Hurricane Andrew (1992)
Kelly, Helena, 9/8/2016

Cumulative Wind Field – Peak Gust Map

KH4

FIGURE 53: HURRICANE OPAL (1995) PEAK GUST MAP IN THE FLORIDA

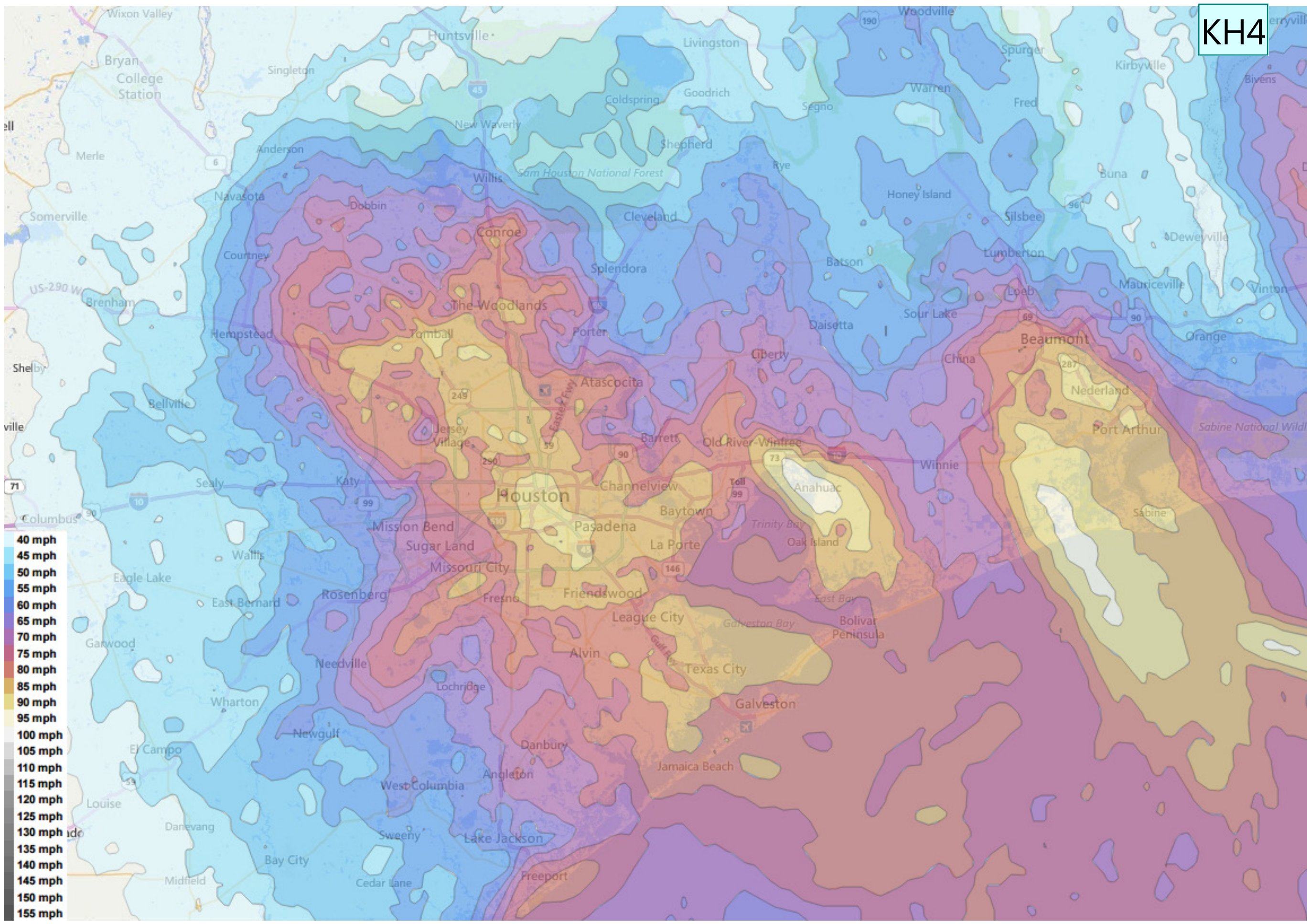


CoreLogic

Slide 31

KH4 Remove "the" before "Florida" in the map title.
Kelly, Helena, 9/8/2016

Cumulative Wind Field – Peak Gust Map



CoreLogic

Slide 32

KH4 Remove "the" before "Florida" in the map title.
Kelly, Helena, 9/8/2016

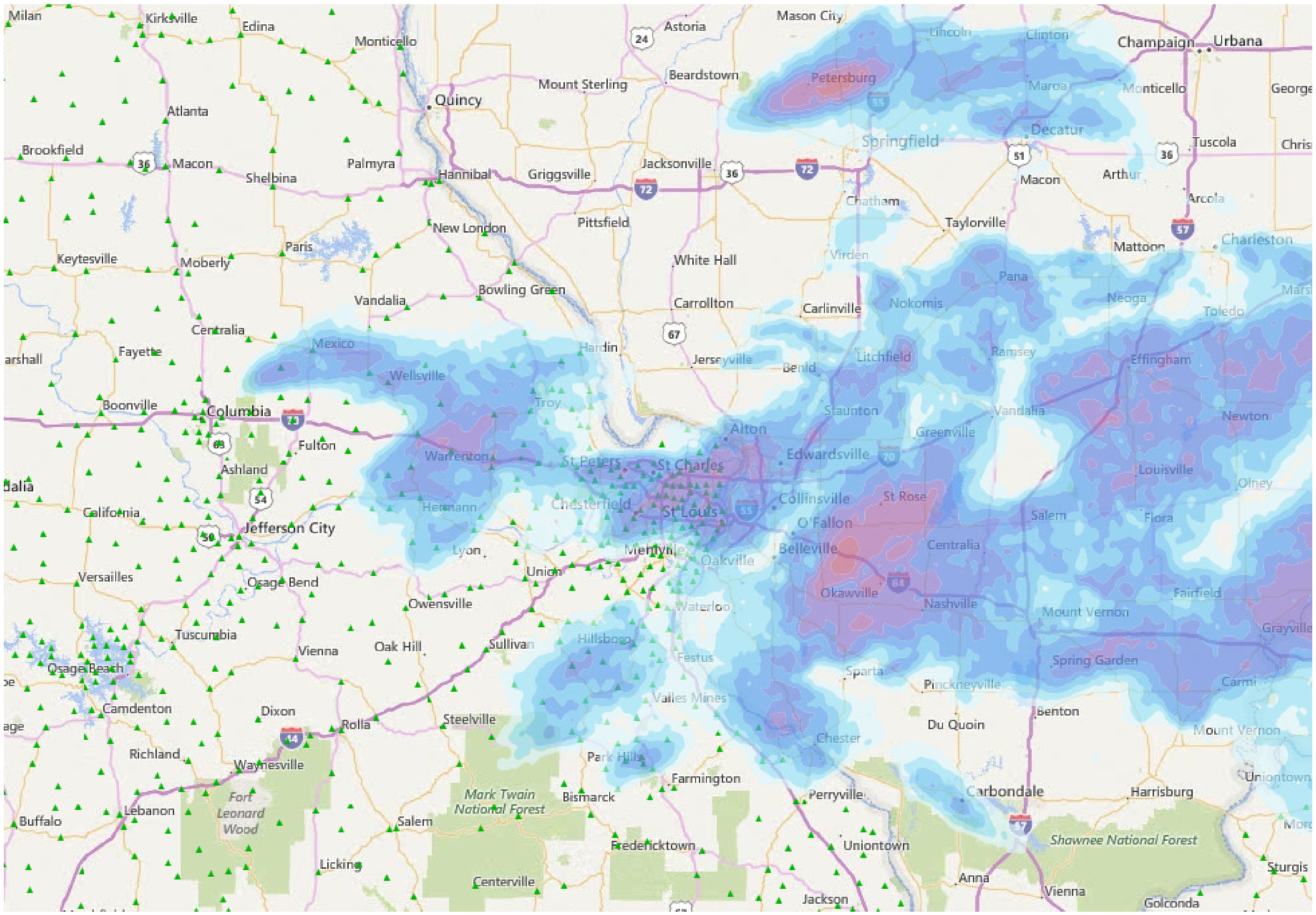
Weaknesses in Using Modeled Events

- High severity events have used simulation
  - Previously mentioned – actual event will rarely be exactly like simulated event
  - Model vulnerability curves set for industry average / engineering estimated damage
    - Claim payments vary by insurance company (differences in claims adjusting)

Weather Forensics in Claim estimations

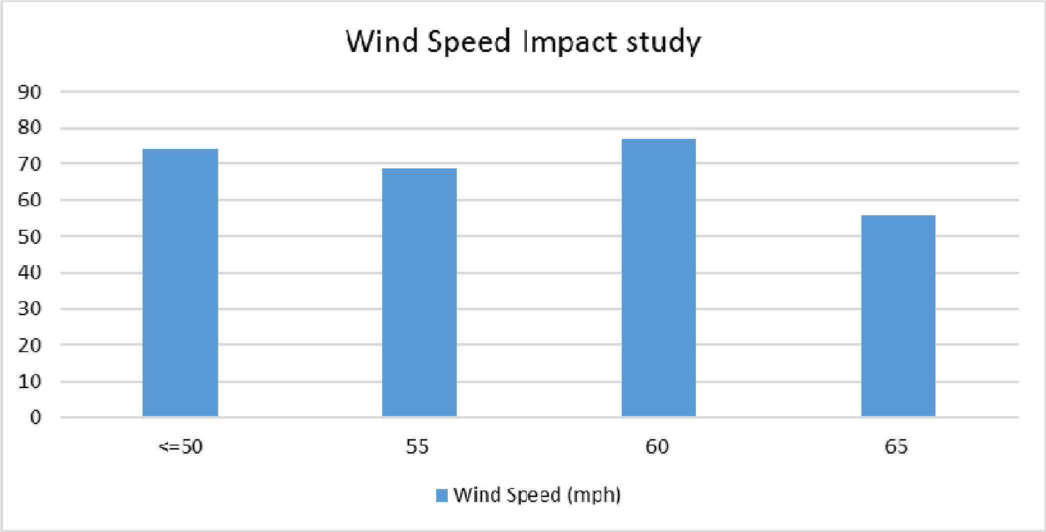
- Use actual event information in a "real time" environment
  - First estimates are available within an hour
- Loss estimates are calibrated to the individual insurance company's own claim adjusting
- No need to run full cat model to produce estimate / range
-

May 11, 2016 Storms - Wind

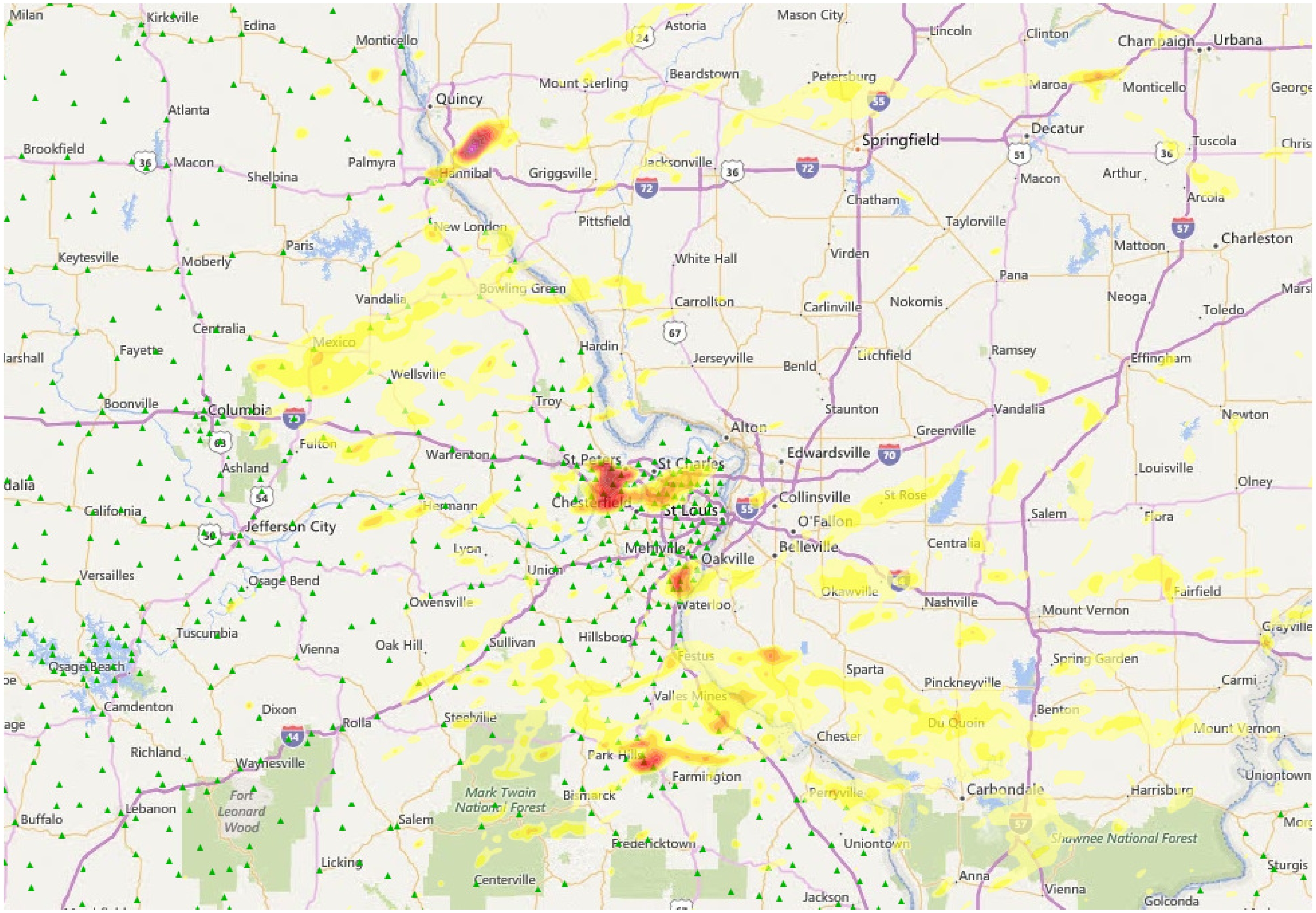


May 11, 2016 Storms - Wind

Wind Speed (mph)	# of locations
<=50	74
55	69
60	77
65	56
Grand Total	276

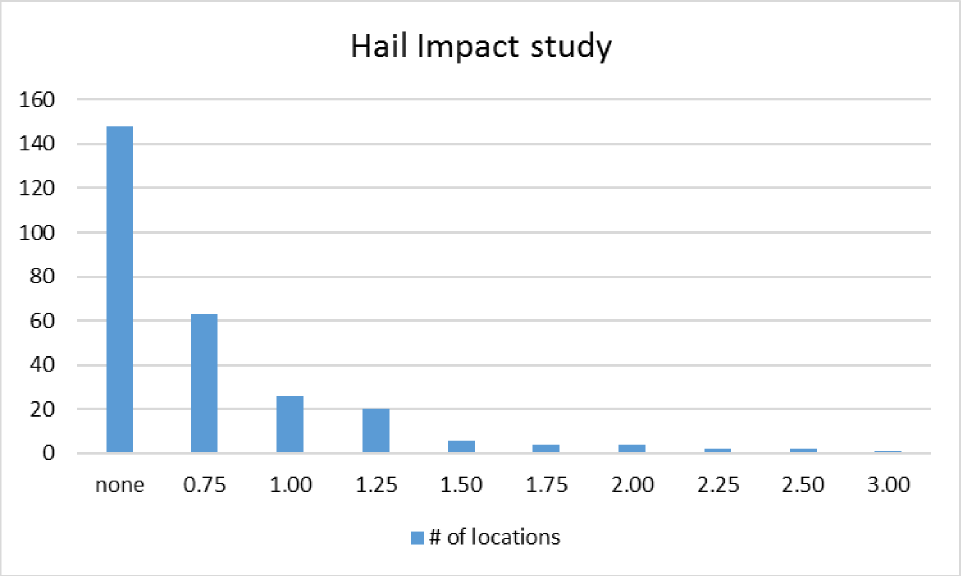


May 11, 2016 Storms - Hail



May 11, 2016 Storms - Hail

Hail Diameter	# of locations
none	148
0.75	63
1.00	26
1.25	20
1.50	6
1.75	4
2.00	4
2.25	2
2.50	2
3.00	1
	276



CoreLogic

May 11, 2016 Storms - Hail

			Est damage range (90th %)			
Hail Diameter	# locs	Total TIV	Min %	Max %	Min $	Max $
none	148	639,260,000	0.00%	0.00%	-	-
0.75	63	293,740,000	1.25%	2.50%	3,671,750	7,343,500
1.00	26	100,450,000	1.50%	3.50%	1,506,750	3,515,750
1.25	20	95,050,000	2.00%	4.50%	1,901,000	4,277,250
1.50	6	22,260,000	2.50%	5.50%	556,500	1,224,300
1.75	4	17,600,000	3.50%	6.00%	616,000	1,056,000
2.00	4	11,760,000	4.50%	7.50%	529,200	882,000
2.25	2	8,980,000	4.50%	8.50%	404,100	763,300
2.50	2	8,620,000	5.00%	10.00%	431,000	862,000
3.00	1	4,680,000	6.00%	11.00%	280,800	514,800
Grand Total	276	1,202,400,000			9,897,100	20,438,900
				midpoint of		
				estimates:	15,168,000	

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May 11, 2016 Storms - Hail

		Total $	Avg %	Min %	Max %
Hail Diameter	Total TIV	Hail Loss	Hail Loss	Hail Loss	Hail Loss
none	639,260,000	-	0.00%	0.00%	0.00%
0.75	293,740,000	5,764,360	1.96%	0.80%	3.30%
1.00	100,450,000	2,744,680	2.73%	1.20%	4.00%
1.25	95,050,000	2,898,550	3.05%	1.60%	5.10%
1.50	22,260,000	848,680	3.81%	3.00%	5.60%
1.75	17,600,000	797,030	4.53%	3.80%	6.20%
2.00	11,760,000	616,650	5.24%	4.20%	6.60%
2.25	8,980,000	493,960	5.50%	4.90%	7.80%
2.50	8,620,000	785,280	9.11%	8.00%	9.30%
3.00	4,680,000	402,480	8.60%	8.60%	8.60%
Grand Total	1,202,400,000	15,351,670	2.73%	0.80%	9.30%

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Thank You & Questions

For additional information, visit www.corelogic.com

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