1.3 CLAIMS ANALYSIS STUDY OF MAY 24, 2011 HAILSTORMS IN DALLAS-FORT WORTH

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1. INTRODUCTION

Since the 1940s, considerable knowledge about damaging hailstorms has been gleaned from crop-hail insurance data. Hail-related losses generally were thought to be better documented by crop-hail insurance companies than by property insurers, who did not distinguish between hail, wind, tornado, rain, or lightning losses (Changnon 1972, 1977; Changnon et al. 2009). Crop-hail loss data historically had been used by Dr. Stanley A. Changnon to understand the spatial and temporal aspects of economic losses attributed to hailstorms, and he used the crop-hail loss data as a proxy to estimate total economic loss data across the nation. The lack of property-hail loss data was noted by Changnon as a key problem in conducting economic analyses of hail losses (1999).

The Insurance Institute for Business & Home Safety (IBHS) obtained from five of its member insurance companies, property claims and policy-in-force data for more than 67,000 residential properties located in 20 ZIP Codes in an area affected by a series of thunderstorms that produced significant hail in the Dallas-Fort Worth (DFW) metroplex on May 24, 2011. The storms caused an estimated $876.8 million in insured losses to property and automobiles, according to the Texas Department of Insurance.

Rather than examining the total economic losses, for this study IBHS evaluated the importance of roofing material type and age with regard to roofing resiliency to hailstone impacts. Additionally, the study focused on evaluating the relative damage costs associated with roofing systems versus wall systems and provided a comparison of WSR-88D radar-estimated hail sizes to damage levels seen in the claims data. The methodology for selecting the 20 ZIP Codes for inclusion in the study is described. Recommendations for improved data collection and quality of insurance claims data, and guidance for future property insurance claims studies are summarized. Studies such as these allow insurance underwriters and claims adjusters to better evaluate the relative performance of various roofing systems and other building components as a function of hail size and the aging of the building components.

IBHS has conducted several studies regarding damaging hailstorms on behalf of the property insurance industry (Cook 1995; Devlin 1997, IBHS 2005). Ongoing hailstorm research programs at IBHS include in-situ hail measurement field research, laboratory hail impact testing of various building materials and component systems, and closed insurance property claims studies following damaging hail events. Hail is of particular interest to the insurance industry because of large insured losses that average more than $850 million annually, which exceed those of every other country in the world (Changnon et al. 2009). The threat of large property losses due to hailstorms is increasing as a result of the construction of more new homes and businesses each year along with modern development trends that place houses closely together on small lots.

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2. FACTORS AFFECTING HAILSTORM RISKS

There are several factors that may affect the risk of building damage during a hailstorm. As Changnon and coauthors noted, many of these factors are specific to the thunderstorm conditions, while others are specific to the item being impacted, i.e., buildings or crops (2009). In some cases, the risks have been studied in previous field studies or in laboratory testing. Some storm characteristics and building characteristics affecting the risk include:

1. Building Materials: Laboratory testing has indicated the size threshold for damage for 3-tab shingles was as low as 1 in. diameter hail, while the threshold for other products such as concrete tiles was 2 in. diameter hail. Damage thresholds from field observations were found to be slightly lower than the laboratory tests (Marshall, Herzog, Morrison, & Smith, 2002). Data regarding the impact resistance of non-roofing materials from the field or laboratory are more scarce, as there are no impact resistance standard tests for these materials, other than for windborne debris.

2. Material Age: All building materials are subjected to the elements, including high temperatures, freezing conditions, wind, water, and UV radiation. Roof surface temperatures more than 80ºF higher than the air temperature have been recorded. Freezing temperatures can cause products to undergo freeze-thaw cycles. These extremes can cause the materials to become thinner or more brittle. Observations from a Roofing Industry Committee on Weather Issues (RICOWI) study of the May 2011 Dallas-Fort Worth event found that older roofing materials had reduced resistance to hailstone impacts (2012). The standard test methods for impact resistance of roofing materials test products in their new state and do not take aging into account (UL, 2012; FM, 2005).

3. Impact Resistance Rating of Roofing Material: Roofing products are either un-rated for impact resistance or are rated Class 1-Class 4, as determined by the performance of new samples of the product when subjected to one of the standard impact test methods which use steel balls or pure ice balls to simulate hail (UL, 2012; FM, 2005). New Class 1 products meet certain performance criteria when impacted by balls up to 1.25 in. in diameter, while Class 4 products meet the same criteria when impacted by 2 in. balls. The ratings do not guarantee that no damage will occur in a hailstorm, but higher-rated products should theoretically reduce the severity and frequency of damage as compared to un-rated or lower-rated products.

4. Sheltering of the Building: If a portion of the building is sheltered by an overhanging tree or, in the event of wind-blown hail, is sheltered by a taller building upstream, a building may be protected partially from hailstone impacts.

5. Wind Speed and Direction: Hailstorms primarily affect the roof system, especially when there is little wind and hailstones fall vertically. However if there are strong winds associated with a thunderstorm, the hailstones may be propelled at an angle (Changnon et al. 2009), leading to more wall, window, or door damage. Additionally, certain roof slopes that are more perpendicular to the predominant wind flow direction, and hence more perpendicular to the hail impact, often have enhanced damage compared to roof slopes facing other directions. Very high wind speeds also may increase the speed of the hailstones at impact, resulting in a larger kinetic energy and force at impact, and thus, more damage.

6. Hailstone Size: The National Weather Service (NWS) defines 1 in. diameter hailstones as the threshold criteria for severe hail. Larger, more massive hailstones have a larger kinetic energy at the point of impact, which means that for all else being equal, they apply a larger, more damaging force at impact. A higher density hailstone also will have a larger impact momentum (all else being equal), as compared to a less dense hailstone of the same diameter.

7. Hailstone Hardness: Some hailstones are very hard, while others are soft and slushy. IBHS is conducting research to assess the hardness of natural hailstones and to develop ways to produce laboratory ice balls that have similar hardness characteristics. Generally, it is expected that harder hailstones will produce greater damage to most building products.

3. HISTORY OF CROP-HAIL INSURANCE DATA FOR ASSESSING LOSSES

In 1948, the crop-hail insurance industry established an industry-wide association to systematically archive all hail and wind loss data (Roth 1949; Changnon and Changnon 1997; Changnon 1972, 1999), leading to more complete datasets. The crop-hail insurance data integrated insured losses with hail activity measured with networks of hailpads and hail observations (Changnon 1970, 1971). These data have been recorded at the county level for the entire U.S. since 1948 (Changnon and Changnon 1997). However, it should be noted that although the Crop-Hail Insurance Actuarial Association (CHIAA) includes approximately 90% of all crop-hail insurance in the U.S. (Changnon and Changnon 1997), an earlier study (Changnon 1972) showed that most of the crop value in the U.S. (80%) is typically not insured.

In the 1940s, the mean of hail-related annual crop losses in the U.S. was estimated to be $100 million (Lemons 1942). In the 1970s, crop losses were about 10 times greater than property losses (Friedman 1976). However, that is no longer true. Today, average annual property losses attributed to hail damage exceed crop-hail losses by approximately $270 million (Changnon et al., 2009).

The lack of property-hail loss data was noted by Changnon as a key problem in conducting economic analyses of hail losses (1999). However, Changnon and coauthors noted that property insurance data were more reliable than NWS Storm Data, which often severely underestimated the true losses (2009). Thus, studies on hail-property losses and improved data quality and quantity are needed.

4. MAY 24, 2011 HAILSTORM

On May 24, 2011, a series of thunderstorms that produced significant hail moved through the DFW metroplex causing an estimated $876.8 million in insured property and automobile damage according to the Texas Department of Insurance. While a very costly event, this DFW storm still did not exceed losses from a 1995 storm which caused property losses of $1.1 billion (Hill 1996; IBHS 1998).

4.1 *Meteorological Conditions*

The severe weather event that occurred on May 24, 2011, was well-forecast with a large upper level trough which moved across the Rockies and into the Plains. A surface cyclone developed in the panhandle regions of Texas and Oklahoma with strong upward motion, strong vertical wind shear, and a very moist air mass near the surface.

By the early morning hours of May 24, a Public Severe Weather Outlook was issued by the Storm Prediction Center (SPC) (2011). A shortwave trough moved out of the Rockies, while a dryline pushed toward central Oklahoma, Texas, and Kansas providing a focusing mechanism for severe thunderstorm development. According to Figure 1, SPC forecast a 45% chance of severe hail (shown in the pink shaded area) in the Dallas-Fort Worth metroplex, with a higher probability of 60% (shown in the purple shaded area) just a short distance to the northwest. Hail over 2 in. in diameter (significant severe weather) also was forecast for Dallas-Fort Worth with a 10% probability within 25 miles of a point (shown in the black hatched area).

As a result of this high-risk environment, several lines of thunderstorms passed over DFW. According to the Local Storm Reports (LSR), more than 50 tornadoes were reported along with more than 200 reports of severe hail across the country, including many around the DFW metroplex (SPC 2011b). It is important to note that there were 12 reports of hailstones 2 in. in diameter or larger within Dallas, Tarrant, Collin, and Denton Counties (SPC 2011b), which is the maximum size to which impact resistant roofing products are tested (FM 2005, UL 2012). Three reports were for extremely large hail in excess of 4 in. in diameter. These data were used in part to select areas of focus for the DFW claims study, as described in section 5.1.

4.2 *Radar Observations*

Many algorithms have been developed to produce analysis products from base radar data. The original Weather Surveillance Radar-1988 Doppler (WSR-88D) hail algorithm was used to indicate whether or not a storm depicted on radar was producing hail (Petrocchi 1982). In 1998, researchers from the National Severe Storms Laboratory (NSSL) developed an enhanced hail detection radar algorithm. The enhanced algorithm produced additional beneficial information such as the probability of hail, the probability of severe hail, and the maximum expected hail size (Witt, 1998). Figure 2 provides a representation of the interpolated maximum estimated size of hail (MESH) as detected by the KFWD WSR-88D hail detection algorithm on the evening of May 24, 2011. The swath of largest radar-estimated hailstones (shown by orange and red) is oriented from west-northwest to east-southeast, and covers large portions of Dallas and Tarrant Counties.

Like the LSRs, radar data were utilized to select areas for inclusion in this project, as discussed in section 5.1. It should be noted that the largest radar-estimated hail sizes shown in Figure 2 are not spatially well-correlated with the largest hail sizes given in the SPC LSRs. This could be due to lack of observations in the LSRs where the largest radar-estimated hailstones were depicted, such as in southeastern Dallas County. There also could be discrepancies due to errors caused by distance from the radar, coarse temporal resolution, and the radar volume extending thousands of feet above the ground surface. It also should be noted that single-polarization radars struggle to differentiate heavy precipitation from hail. They also cannot effectively differentiate between a large quantity of small hail and a small quantity of large hail. However, the NWS recently completed a project to upgrade all of the WSR-88D radars to feature dual-polarization capability, which will improve their ability to determine the presence of hail. This upgrade began in March 2011, and as of the time of this event the KFWD radar had not been upgraded. However, all of the WSR-88D radars have now been converted (National Weather Service Radar Operations Center 2013). The relationship between radar-estimated hail size and damage rates is discussed in section 7.3.

4.3 *Post-Disaster Damage Survey in DFW*

RICOWI, of which IBHS is a sponsoring member, organized a week-long damage survey in a large area of DFW. The goal of the survey was to describe the roof assembly performance and modes of damage or hail resistance for both low-slope and steep-slope roofing systems. The Dallas-Fort Worth area was specifically targeted because of the high presence of impact resistant roofs due to insurance premium credits required by the Texas Department of Insurance (TDI) from 1998-2003, which are now optional. The findings of the study have been reported (RICOWI 2012).

IBHS engineers participated in the RICOWI study, and used knowledge gained about the damaging event and typical construction in the DFW area to select regions for further investigation using property claims and policy-in-force data, as described in section 5.1.

5. METHODOLOGY AND DATA COLLECTION

Project design required careful selection of data fields and areas for investigation. This was done to maximize the ability to study the effects of many variables that potentially contribute to hail damage to buildings. Researchers used observations from the RICOWI surveys, radar data, LSRs, and information from member insurance companies to select areas of the metroplex to investigate. A third-party claims estimating and claims management company, Xactware, collected the insurance carriers' policy data and matched them with their claims data. To the extent that the data were available, they were gathered for all policies-in-force and all claims. Much effort was put into data quality control to eliminate sources of error. The data were concatenated into a single, uniform format.

5.1 *Selection of ZIP Codes*

The communities included in this study were selected primarily to provide variety in roofing materials, ages of houses, and radar-estimated or publically-reported hail sizes. Additionally, observations about the sizes, severity, and frequency of hail impacts seen during the RICOWI field study were considered. Lastly, member insurance company input regarding preliminary percentages of claims and presences of impact resistant roofing products were considered in making the selections.

Table 1 provides a summary of the ZIP Codes selected for this study, and tabulates some of the key reasons for selection. Participating member companies were asked to provide policy-in-force and claim data for every policy written within these ZIP Codes. A map of the selected ZIP Codes categorized by estimated hail severity is also included in Figure 3.

5.2 *Data Fields*

Data fields selected for analysis focused on the main residential structure. Losses related to other attached structures, additional living expenses, and other claims costs not associated with the main structure were not included in the dataset. Basic policy information such as the location, Coverage A amount (the cost to replace the primary dwelling structure in the event of a total loss), and primary roof covering type were included. Additionally, damage estimates for certain components were included and grouped into the following categories for analysis purposes: roof, wall, door, window, other.

6. DATA SUMMARY

The dataset for this project included 67,100 residential policies from five IBHS member insurance companies from the May 24, 2011 DFW hailstorm. A total 6,697 of the policies had claims; of those, 6,490 had roofing-related claims. The locations of all exposures in the study with and without claims are provided in Figure 4. The ages of the buildings ranged from older than 150 years to less than a year old. There were more than 200 homes for which no age information was available.

As shown in Figure 5, asphalt composite shingles, of 3-tab or architectural style, made up over three-quarters of the dataset. Additional roofing materials included tile, metal, wood, and slate. A small number of roofs with other materials were reported, but sample sizes were so small that those exposures were removed from the dataset prior to analysis, leaving a sample size of 66,883 policies. Surprisingly, a large percentage of policies had no information available on the primary roof covering material. When a claim was filed, data on the roof cover were generally available and these data were used by Xactware to fill in missing data. Consequently, the nearly 20% of properties where roof cover was unknown were properties where coverage information was available but no claim had been filed.

7. ANALYSIS

The frequency and severity of residential property claims were investigated by roof cover category to determine vulnerabilities associated with various materials. Additionally, frequency and severity of damage to windows, walls, doors, and other non-roofing components were investigated and compared to roofing component damage. Claim frequency and severity were also investigated in regards to age of homes.

The term “claim frequency” of a category x (i.e. asphalt roofs) can be described by:

$$CF_x = \frac{c_x}{p_x} \tag{1}$$

where c_x is the number of claims in category x, and p_x is the number of policies x. The term “claim severity” can be described by:

$$CS_x = \frac{\sum l_x}{c_x} \tag{2}$$

where l_x is the claims losses in dollars. The term “normalized average claim severity” is

$$NCS_x = \frac{\sum \frac{l_{x_n}}{CovA_{x_n}}}{c_x} \tag{3}$$

where n is an individual structure in category x, and $CovA_x$ is the Coverage A limit. The normalized average value provides a way to evaluate damage severity as a ratio of the value of the home, so damages to very large, expensive homes can be compared with damage to smaller, less expensive homes.

7.1 *Roof Damage*

For purposes of damage estimates, the roof system included the roof covering material along with other roofing components such as flashing, vents, underlayment, and sheathing, among others. It should be noted that there were 207 exposures in which the properties had a claim but it was not associated with the roofing system. Those 207 exposures are not included in the analysis of roofing damage.

The results indicated the claim frequencies from this event were highest for metal and wood roofs as shown in Figure 6. However, the sample sizes of those materials as compared to the sample size of asphalt shingle roofs were quite small. The claim severities for asphalt shingle roofs and tile roofs were lower than the claim severities for metal, slate, and wood roofs, as shown in Figure 7. Metal and wood roofs still had the highest claim severities, even after normalizing by the Coverage A limit of the insurance policy as shown in Figure 8.

Another way to examine the severity of roofing losses associated with this event is the average roofing loss per exposure, which is illustrated in Figure 9. This represents a way to evaluate the expected payout for a property with particular roofing characteristics. For example, this graph illustrates that for each insured property with a tile roof, an insurance carrier could expect to pay out an average of $1,027 in roofing-related losses following an event similar to this hailstorm in a similar location. Carriers could expect to pay out the highest amounts for metal and wood roofs, which reflects not only their damageability but also their higher material costs.

In recent years, there has been an increased focus on the effects of aging as it affects the durability and performance of materials. In the last decade, IBHS has conducted several studies, which have shown that older buildings have a higher claim frequency in a variety of natural disasters. In some cases, this may be due to changes in building codes requiring stronger construction for new buildings. In other instances, the degradation of the building materials or poor maintenance practices for the older buildings may be responsible. For this study, the ages of homes involved in the Dallas-Fort Worth hailstorm were divided into five-year bins and claim frequencies and severities were calculated for each roofing material. However, there was insufficient data to support statistically robust analysis for materials other than asphalt shingles. It should be noted that the age groups correspond to the ages of the homes, and not necessarily the roofs. For newer homes, some assumptions can be made, namely that the roof is likely the original roof and is therefore the same age as the house.

The results, as shown in Figure 10, indicated the claim frequencies for asphalt shingles tended to increase with increasing age up to about 20 years followed by a slight drop in frequency and a larger rise as the age approaches 50 years. This type of trend has also been seen in wind damage investigations (IBHS 2004). The trend likely reflects the fact that many shingle roofs are replaced in southern states after 20 to 25 years due to aging effects, unless they are replaced sooner because of hail or wind damage.

Average claim severities with respect to age for asphalt shingle roofs are provided in Figure 11. There was a slight increase in average claim severity as the age of the house approached 20 years followed by a slight decline for properties more than 20 years old. Normalized average claim severities for asphalt shingle roof damage with respect to age are depicted in Figure 12. The average roofing losses per exposure were also determined for asphalt singles by age groups and are illustrated in Figure 13. The average loss per asphalt shingle roof exposure exhibits trends that closely reflect the trends in claim frequency shown in Figure 10 with relatively larger losses per exposure as home age approached 20 years and again as it approached 50 years.

7.2 *Component Damage*

In addition to roof damage, hailstorms frequently cause damage to other building systems and components. The results showed roofing-related claims occurred more frequently than those for other building systems as illustrated in Figure 14. Additionally, the claim severities far exceeded those of other building systems for this particular event, with the cost of roofing-related losses more than 10 times higher than for any other component group as shown in Figure 15. More than 90% of the money paid out for claims in this event was paid for roofing repairs.

7.3 *Claims vs. Radar-Estimated Severity*

The spatial distribution of normalized average claim severities are shown in Figure 16. This illustrates the average claim severity calculated from both damaged and undamaged exposures within a given map grid cell. The single grid cell with the highest average normalized average severity was just over 5%. The areas of highest average claim severities were in northwestern Dallas County in ZIP Codes 75063, 75038, and 75062. Hot spots also appeared in ZIP Codes 75006, and 75229 to the east of the areas with the highest average claim severity, in ZIP Code 75181 in eastern Dallas County, and in ZIP Codes 76248 and 76092 in northeastern Tarrant County. The swath of highest damage rates appears to be oriented west-northwest-to-east-southeast, from north-central Tarrant County, into northwestern, central, and eastern Dallas County. Comparing this swath to the radar-estimated hail severity swath in Figure 2 revealed a similar orientation of the swath with largest hail sizes, although the areas of largest radar-estimated hail sizes are shifted south along I-20 in southern Dallas County, which was not included in this study. Based on this comparison, the orientation of the swath with large radar-estimated hail is reasonably well lined up with the swath of locations with highest damage from the claims data despite the fact that radar hail algorithms are not highly accurate in estimating hail sizes.

To allow for a more direct comparison between the normalized average claim severities and radar-estimated hail sizes, open contours of the radar data from Figure 2 were overlaid on the normalized average claim severity data contained in Figure 16. The result of this combination is provided in Figure 17. From this map, it is easier to see the correlation between the northwest-to-southeast orientation of the radar-estimated maximum hail size and the damage severities.

A zoomed-in map of the highest damage area is provided in Figure 18. The area of highest average normalized average claim severity averaging over 4% is shown in red, and was located in the northwestern part of ZIP Code 75038. According to the radar contours in this area, the hail size would have ranged from 1 in. to 2 in., with higher sizes of over 2.5 in. just southwest of the area of highest claim severity.

Claims data were not collected in the area of the highest radar contour just further to the southwest where the hail size was estimated to be larger than 3.5 in. The claims data showed additional hotspots of 2%-3% claims (shown in orange) in the western portion of ZIP Code 75063, the majority of ZIP Code 75062, the north central portion of ZIP Code 75038, and the northwestern portion of ZIP Code 75229. In the western portion of ZIP Code 75063, the hail size was estimated by the radar at 0 to 1 in. in diameter. In ZIP Code 75062, the radar-estimated the hail size at 1 in. to 2 in., while the north central portion of ZIP Code 75038 was estimated to have experienced hail of 1 in. to 1.5 in. The northwestern portion of ZIP Code 75229 was expected to have received 0.5 in. to 1 in. hail according to the radar.

A mathematical spatial comparison between normalized average claim severity and radar-estimated hail sizes over the grid cells was completed. Both the normalized average claim severity values and the radar-estimated hail size values were reclassified into a dimensionless scale from -4 to +4 as outlined in Tables 2 and 3, respectively. Note the negative values represent lower damage values and smaller hail size estimates, while positive values represent relatively larger damage values and hail sizes. The reclassified radar spatial values were subtracted from the reclassified claim severity spatial values. These reclassification schemes were designed so that a negative result from the subtraction would indicate lower damage severity and higher radar-estimated hail sizes, while a positive result would indicate higher damage severity coupled with lower radar-estimated hail sizes. The mapped result of the subtraction is provided in Figure 19.

Subtraction results ranging from -8 to -2 are shown in blue indicating areas characterized by relatively low damages and relatively high radar-estimated hail sizes. Results ranging from -1 to +1 are shown in green to indicate reasonable agreement between the two datasets. These areas had relatively high damages associated with relatively high radar-estimated hail sizes, or had relatively low damages associated with relatively low radar-estimated hail sizes. Results ranging from +2 to +8 are shown in red to indicate areas characterized by relatively high damages but relatively low radar-estimated hail sizes. In areas where there was not much damage, the radar and damage data were generally in reasonable agreement. Based upon radar data alone, the damages were higher than expected in areas of northwestern Dallas County, especially east of the DFW Airport; however ground observations from the RICOWI survey indicated that large hailstones fell in these areas. Damages were lower than expected based on the radar data in north-central Tarrant County, and in central and southeastern Dallas County. As dual-polarization radar algorithms are developed and employed, it is expected that the agreement would further increase for typical built areas.

8. CONCLUSIONS, DATA LIMITATIONS, AND RECOMMENDATIONS

The May 24, 2011 Dallas-Fort Worth hail event caused over $876.8 million in insured property and automobile damages, of which more than $545.2 million were attributed to damages to residential properties, according to the Texas Department of Insurance. Rather than focusing on the event total insured losses as Changnon historically did, for this study, IBHS chose to focus on the damages caused to residential building systems and compared areas of damage to areas of radar-indicated hail.

From this dataset, it was apparent that the majority of damages were associated with the roofing system, with more than 90% of the claims dollars being spent on roofing damage. These results further confirm the idea that roofing-related damages are the largest concern associated with hail events. Brick veneer exterior wall surfaces are common in the Dallas-Fort Worth area where this study was conducted. Hail coupled with very high wind speeds in regions where less hail-resilient wall materials are used may see higher relative rates of damage to walls. Nevertheless, the predominant loss driver is still expected to be damage to the roofing materials.

A comparison of the relative performance of roofing materials revealed that the highest claim frequencies occurred on metal and wood roofs, while the highest claim severities occurred on slate, metal, and wood roofs. However, these products tend to be located on larger and more expensive properties, and when normalized by the Coverage A values, the average claim severity was less than 10% for each product included in the study.

The effect of building age also was examined and is presented for asphalt shingles. The claim frequencies generally increased with age of the home, but no data were available concerning the age of the roof. The claim severities nearly were constant with building age for asphalt products. When the claim severities were normalized by the Coverage A values, there was a noticeable pattern of increasing losses with respect to age for asphalt products.

While this study provided valuable information, there were some limitations associated with the dataset. The lack of data on the ages of roofs limited the ability to determine how roofing material performances degrade due to environmental exposure. Additionally, sample sizes associated with non-asphalt roofing materials were very small, as asphalt roofs are the most commonly-used material in this part of Texas, as well as throughout the country (ARMA 2011; Dixon et al. 2013). Depending on the scope of future projects, it may be beneficial to include commercial properties to allow for examination of other non-asphalt roofing products, or to focus on areas known to have high concentrations of non-asphalt products on residential roofs. Reviews of aerial imagery could be used to identify these areas. Additionally, documentation of the presence of impact resistant roofs is necessary for hail studies.

To gain a better understanding of the performance of a variety of wall materials, it may be necessary to focus future studies on other regions where construction practices differ. Brick wall materials were most common in this area, and these materials generally are less prone to hail damage than other wall materials. The relative performance of various building systems may differ when the materials contained in those systems differ.

To use these kinds of claims analyses for future damage studies associated with a variety of hazard events, additional and better quality data are needed. Increasing the sample size by either including a larger spatial area or incorporating data from additional member insurance companies would be beneficial.

IBHS also has developed a hail field program to make measurements of real hailstones in-situ shortly after they have fallen. Should data from that program be collected in a high-population area, the combination of the ground data coupled with a claims analysis and radar data would greatly enhance the ability to study the correlation between hail properties, damage observations, and loss data.

Changnon (1999) recommended more complete datasets to conduct these kinds of studies, and has demonstrated the value of comprehensive and systematic data collection by the crop insurance industry. IBHS has engaged in discussions with its member companies to determine ways to improve the data collection process to enhance future studies. With the combination of complete data in each of the appropriate fields along with improved radar analyses, researchers will be better able to uncover why some properties are more severely damaged by hail than others.

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Table 1: Selected ZIP Codes and key parameters for selection to provide variation in the dataset.

ZIP Code	City	County	Reasons for Selection				
			Radar-Estimated Severity	Field Observation Severity	Claims %	Impact-Resistant Roofs	Age
75006	Carrollton	Dallas	Low	Moderate			
75007	Carrollton	Denton	Low to Moderate	Moderate			
75019	Coppell	Dallas	Low to Moderate		High		
75038	Irving	Dallas	High	High	High		Mixed
75062	Irving	Dallas	High	High	High		Mixed
75063	Irving	Dallas	High	High	High		Mixed
75068	Little Elm	Denton	Low	High			New
75078	Prosper	Collin		High			
75181	Mesquite	Dallas	High				
75220	Dallas	Dallas	Moderate	Moderate			
75229	Dallas	Dallas	Low	Moderate			
75244	Dallas	Dallas		Moderate			
75253	Dallas	Dallas	Sharp transition from low to high				
76051	Grapevine	Tarrant	Moderate		Low	High	
76092	Southlake	Tarrant	Moderate		Low	High	
76132	Fort Worth	Tarrant	Low to Moderate		High		
76133	Fort Worth	Tarrant	Low to Moderate		High		
76210	Denton	Denton		Moderate			New
76244	Keller	Tarrant			Low		New
76248	Keller	Tarrant			Low		New

Table 2: Reclassification scheme for normalized average claim severity values for use in spatial comparison with radar data.

Original Normalized Damage Severity	Reclassified Damage Severity
0.0% - 0.15%	-4
0.16% - 0.30%	-3
0.31% - 0.50%	-2
0.51% - 1.00%	-1
1.01% - 1.50%	1
1.50% - 2.00%	2
2.01% - 3.00%	3
3.01% - 4.00% +	4

Table 3: Reclassification scheme for radar-estimated hail sizes for use in spatial comparison with normalized average claim severity data.

Original Radar-Estimated Hail Size	Reclassified Hail Size
0.00 in. – 0.50 in.	-4
0.51 in. – 1.00 in.	-3
1.01 in. – 1.50 in.	-2
1.51 in. – 2.00 in.	-1
2.01 in. – 2.50 in.	1
2.51 in. – 3.00 in.	2
3.01 in. – 3.50 in.	3
3.51 in. – 4.00 in. +	4

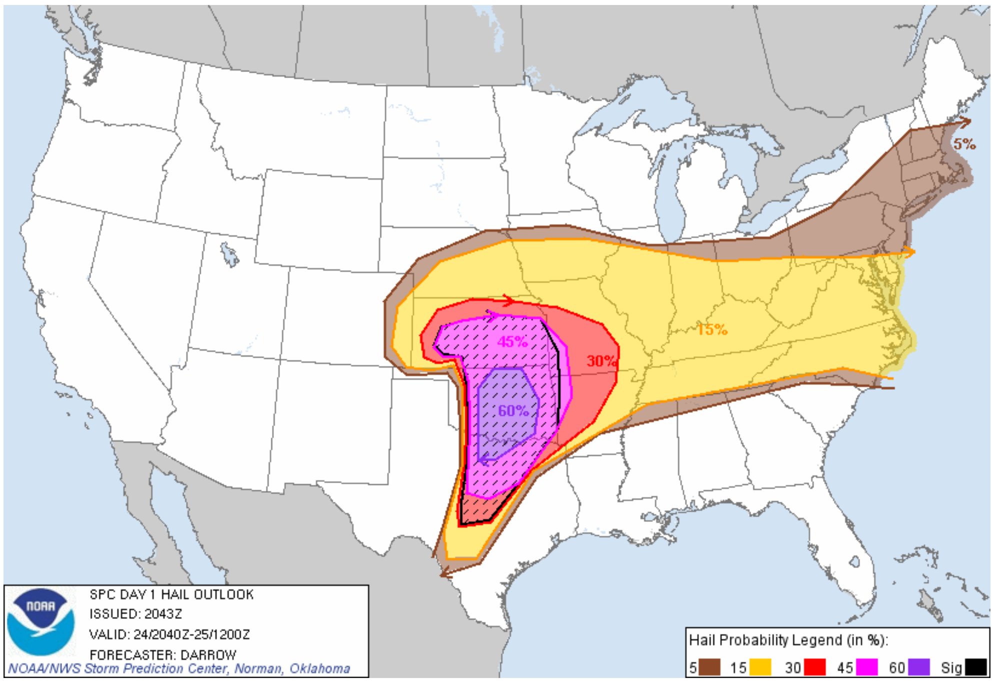

Figure 1: SPC Day 1 Convective Outlook issued at 2043Z on May 24 (2011a).

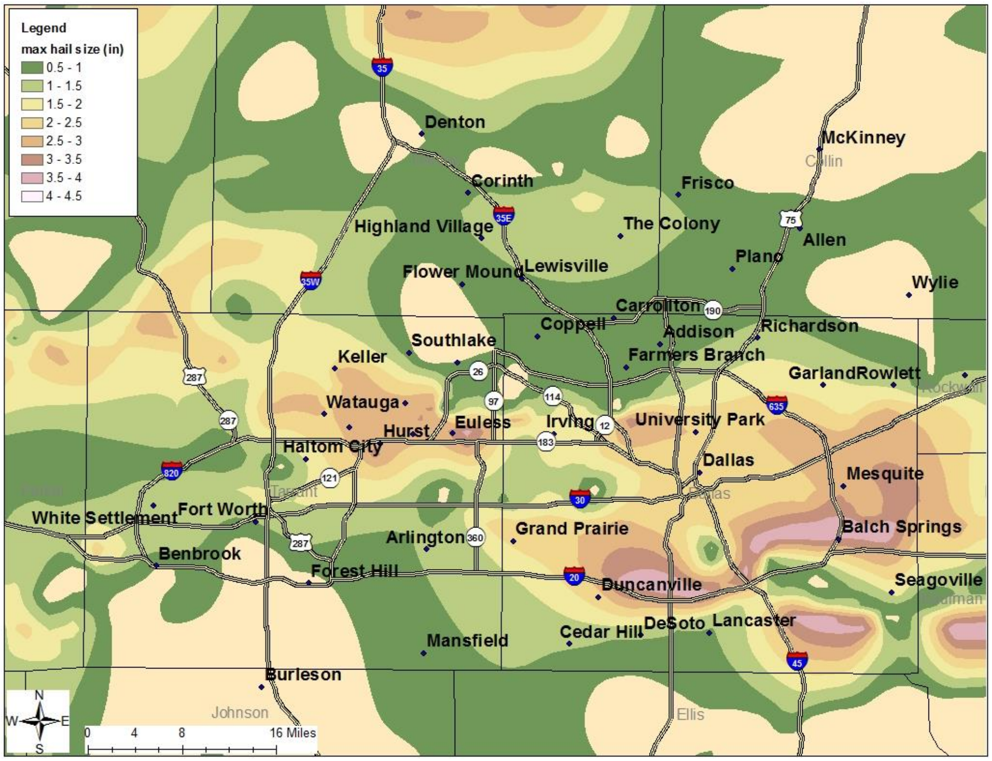

Figure 2: Radar-estimated hail sizes in the DFW area on May 24, 2011.

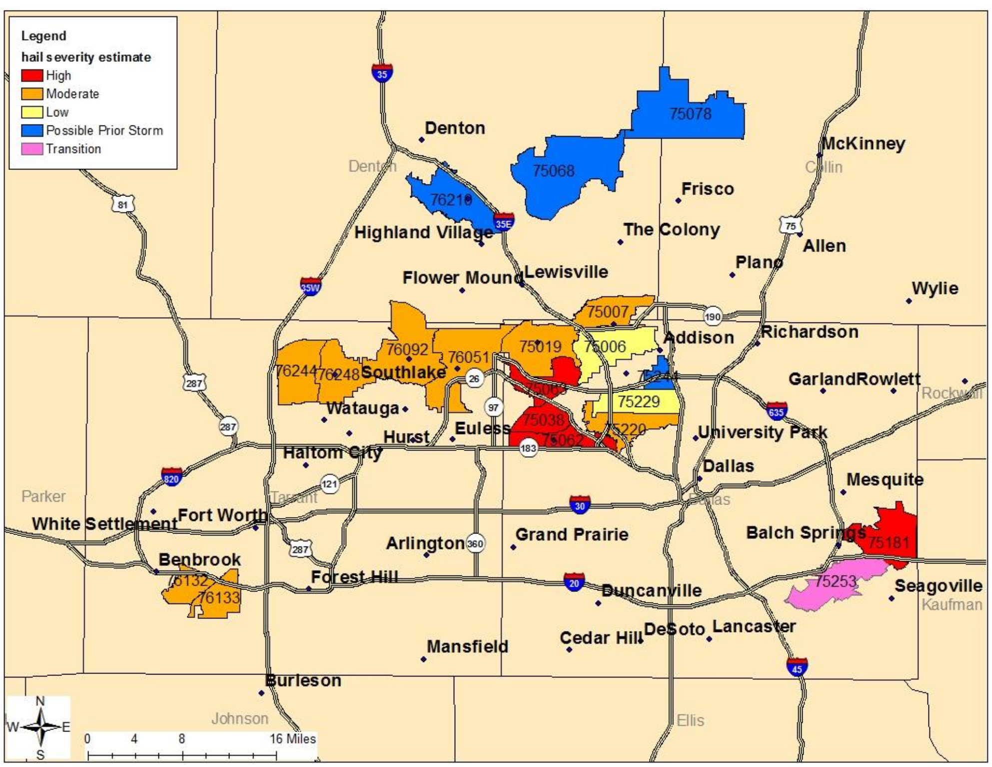

Figure 3: Map of ZIP Codes selected for the claims analysis study in the DFW area.

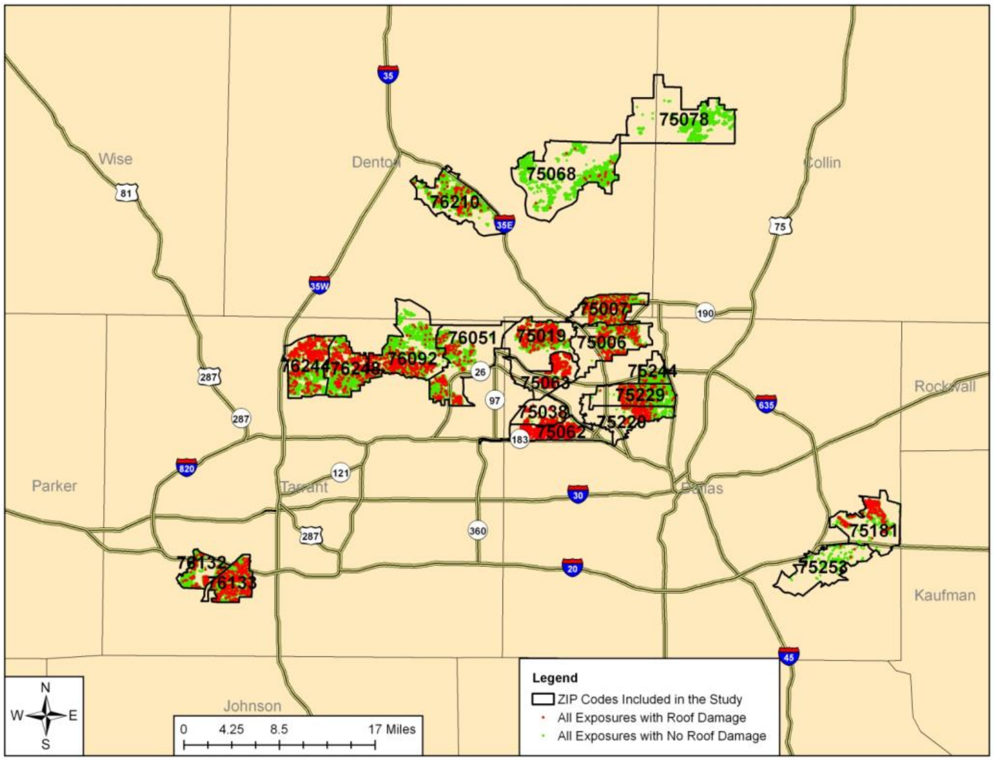

Figure 4: Locations of all exposures with roof claims (red) and without roof claims (green) within the 20 ZIP Codes selected for this study.

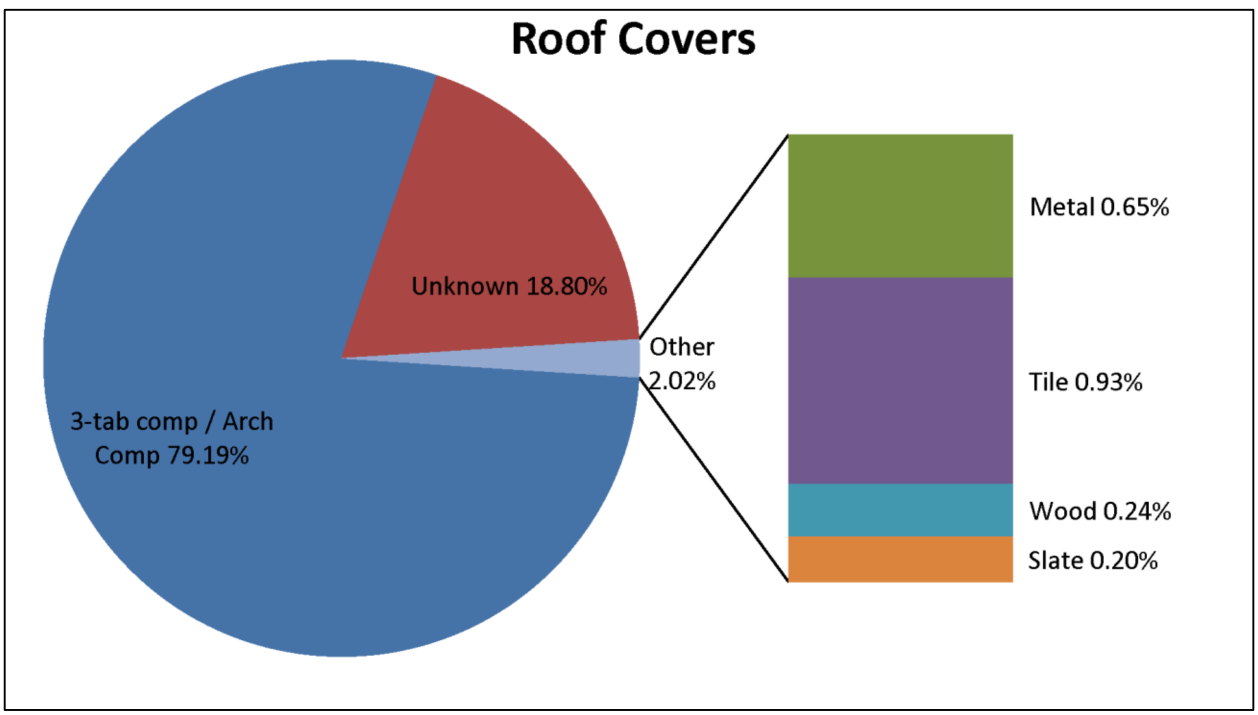

Figure 5: Distribution of roof cover materials for all policies contained in the dataset.

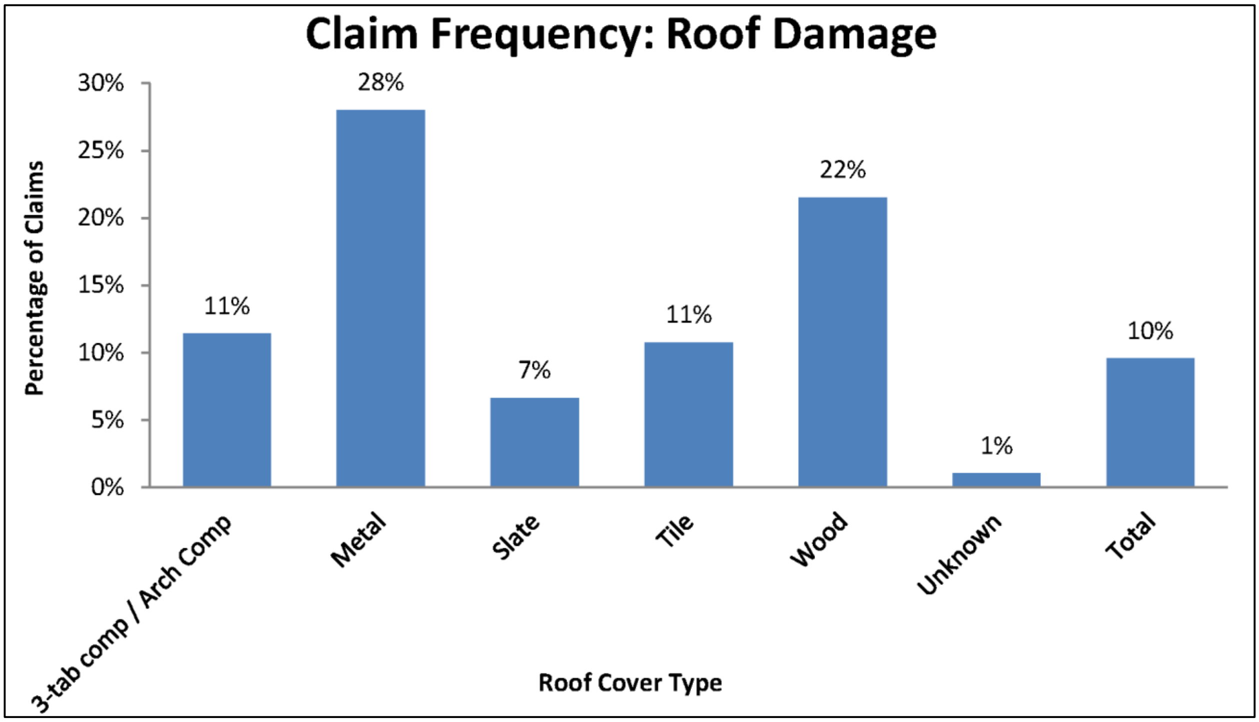

Figure 6: Percentage of policies where claims were filed by roof cover type.

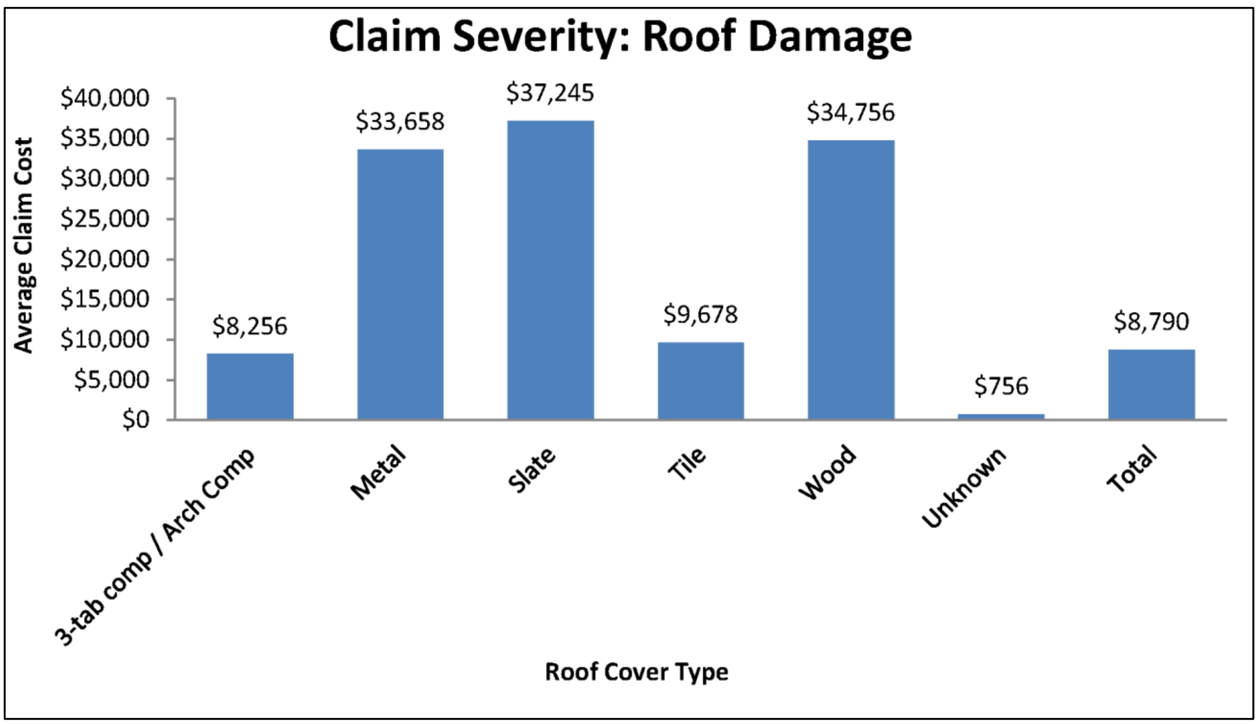

Figure 7: Average claim severity for roofs where claims were filed by roof cover type.

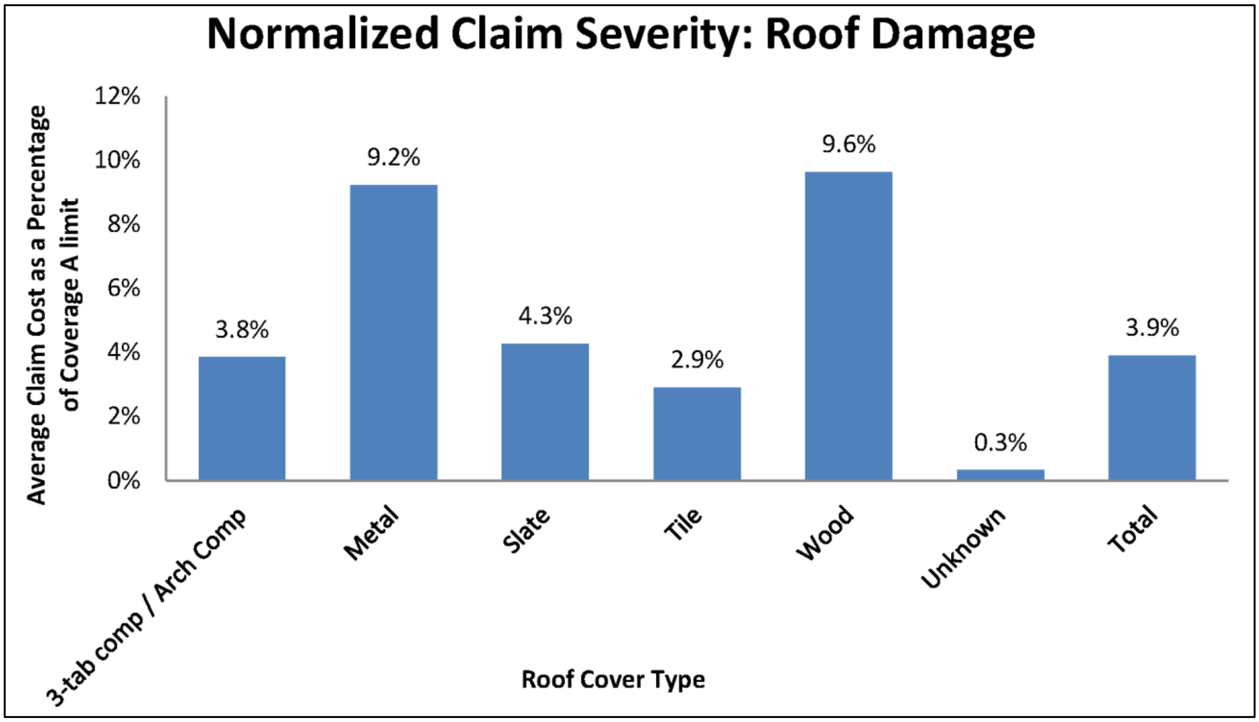

Figure 8: Normalized average claim severities for roofs where a claim was filed by roof cover type. Data are normalized by the Coverage A limits.

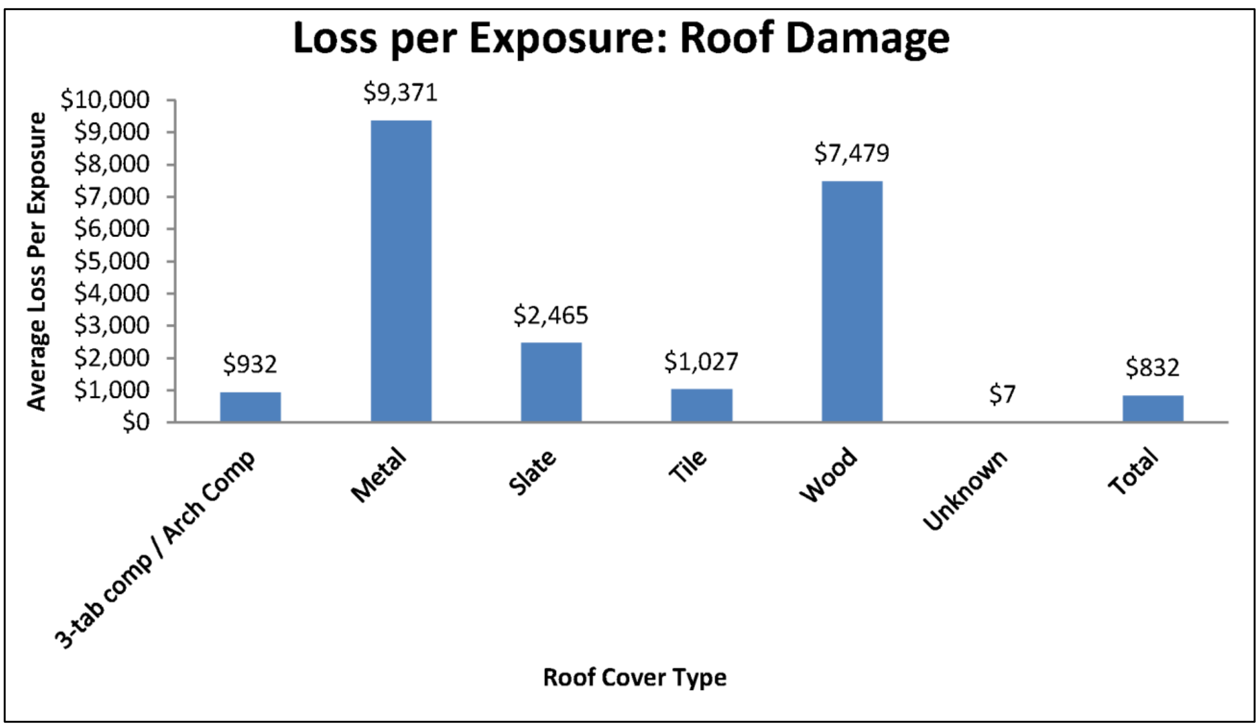

Figure 9: Average expected roofing-related losses per insured exposure by roof cover type.

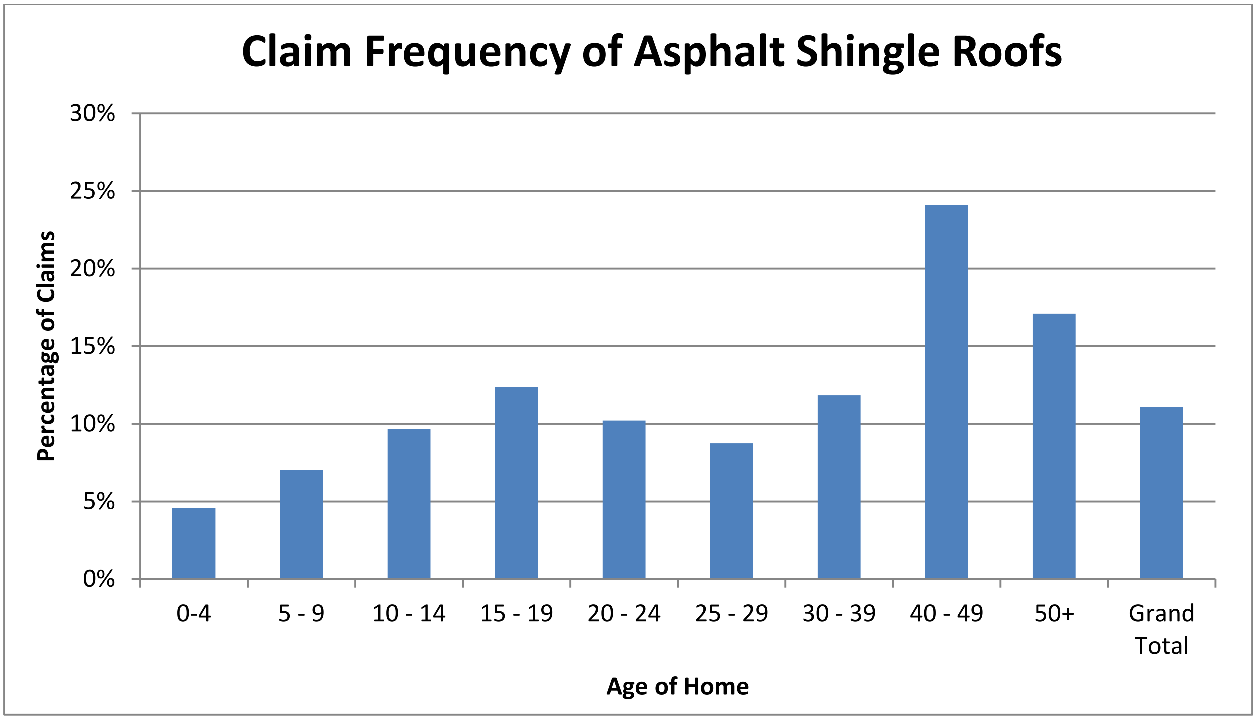

Figure 10: Claim frequencies with respect to age for asphalt roofs.

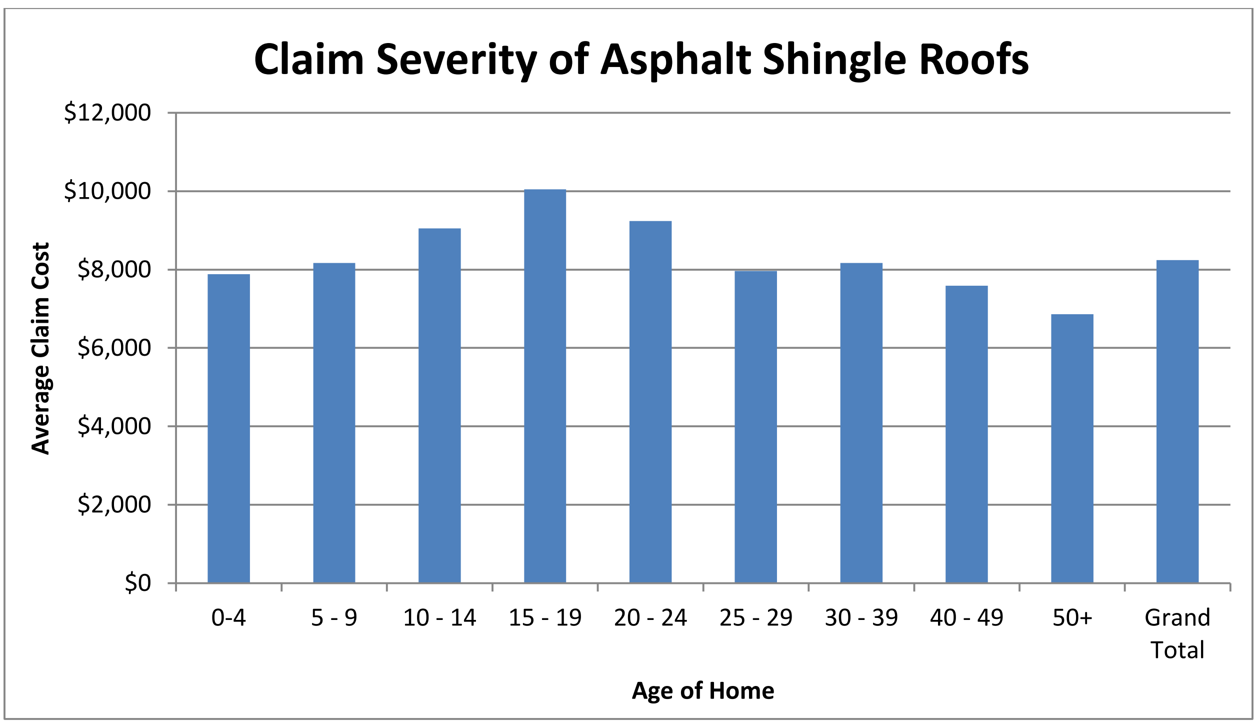

Figure 11: Claim severities with respect to age for asphalt roofs.

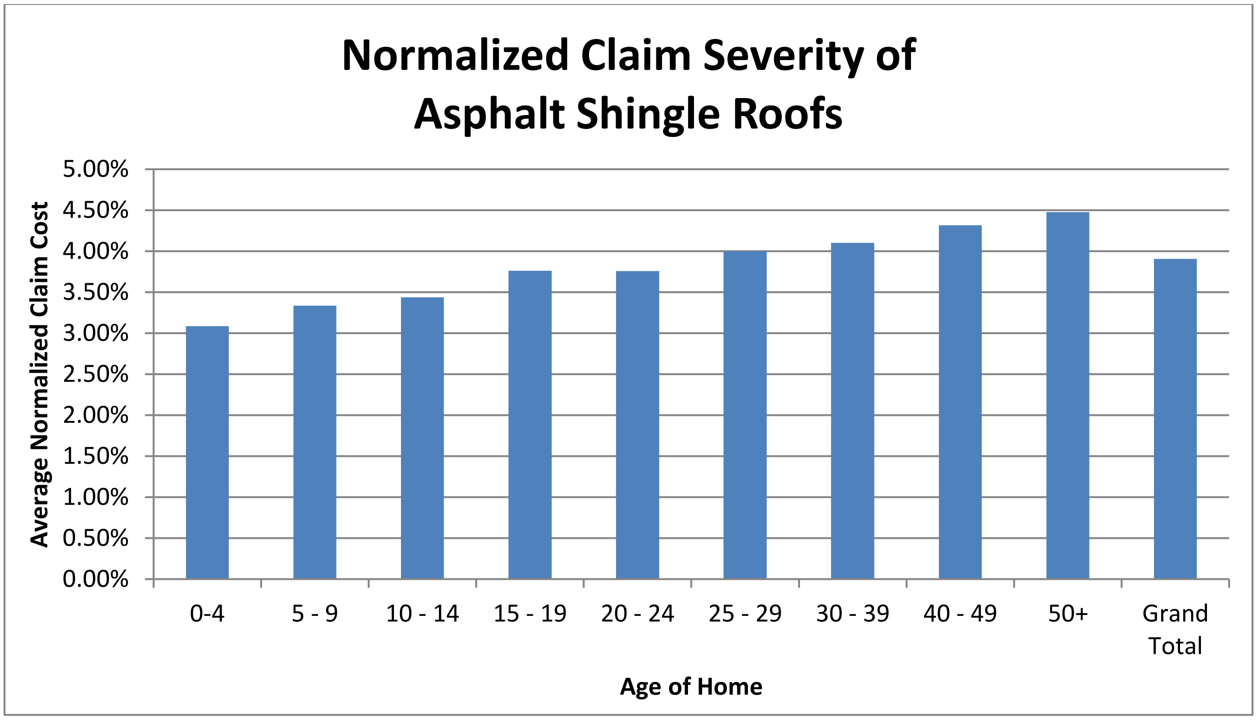

Figure 12: Normalized average claim severity with respect to age for asphalt roofs.

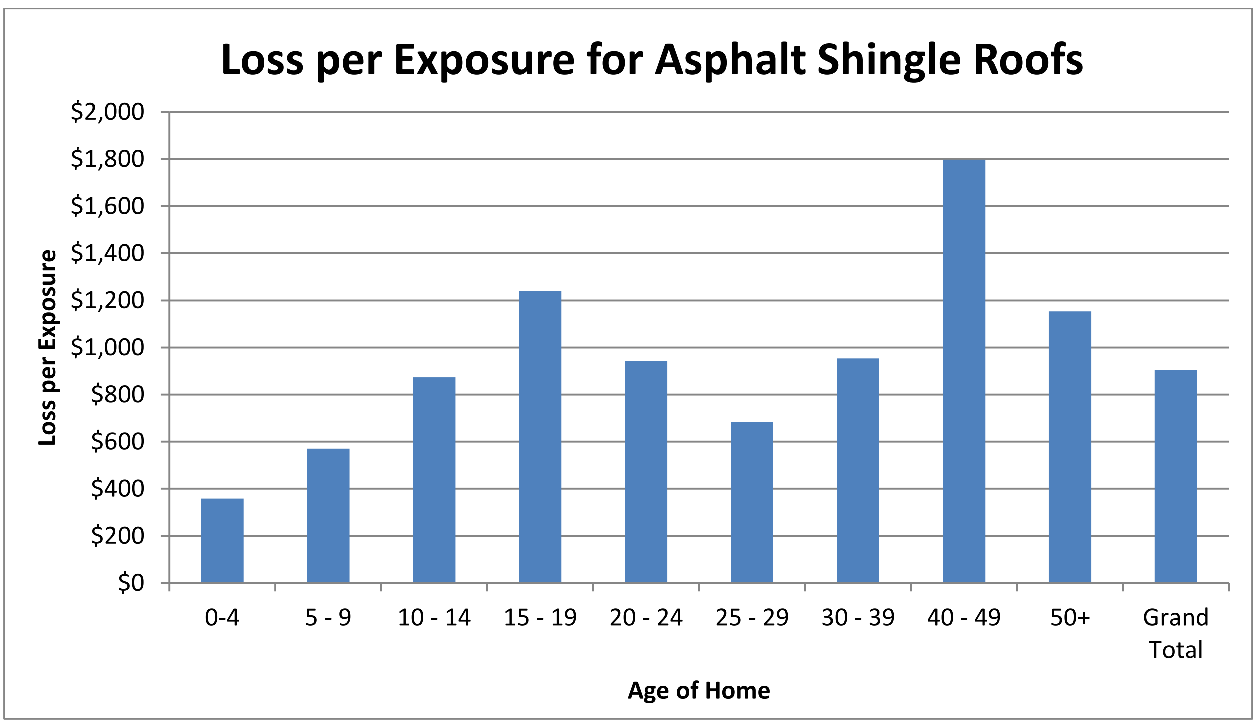

Figure 13: Distribution of expected roofing-related losses per insured exposure by age for asphalt shingle roofs.

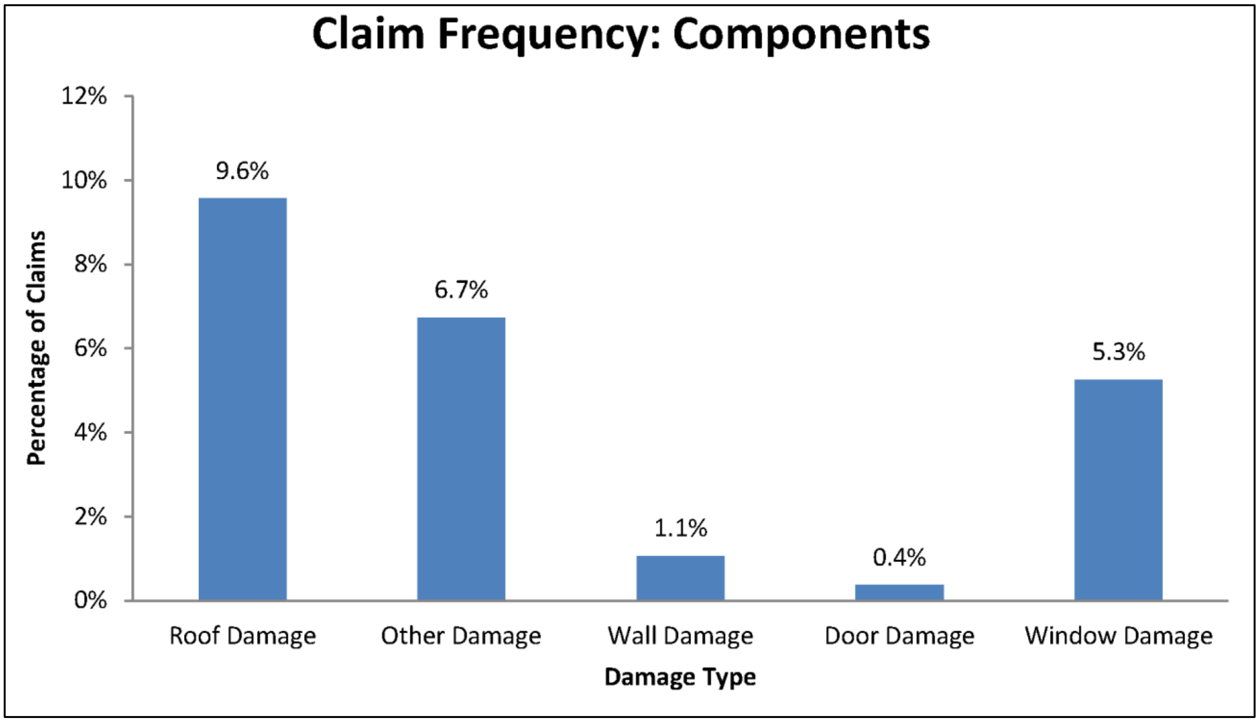

Figure 14: Frequencies of claims with losses associated with major building component groups.

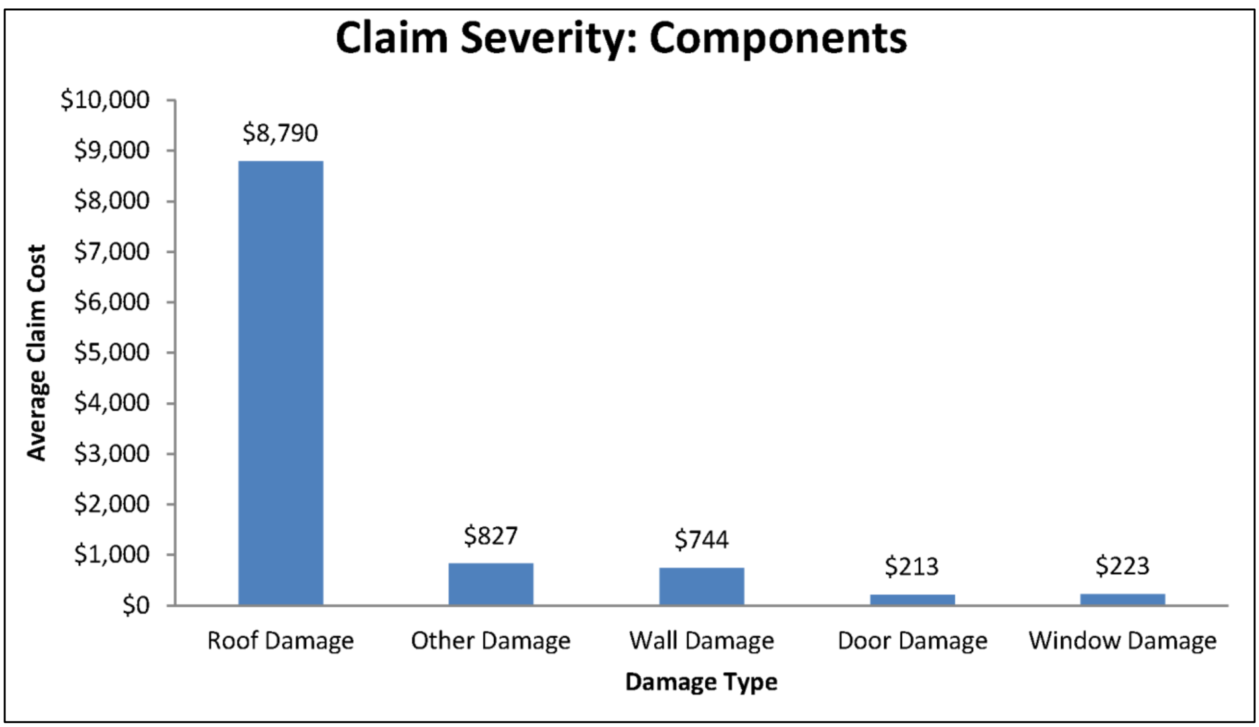

Figure 15: Average claim costs associated with major building component groups.

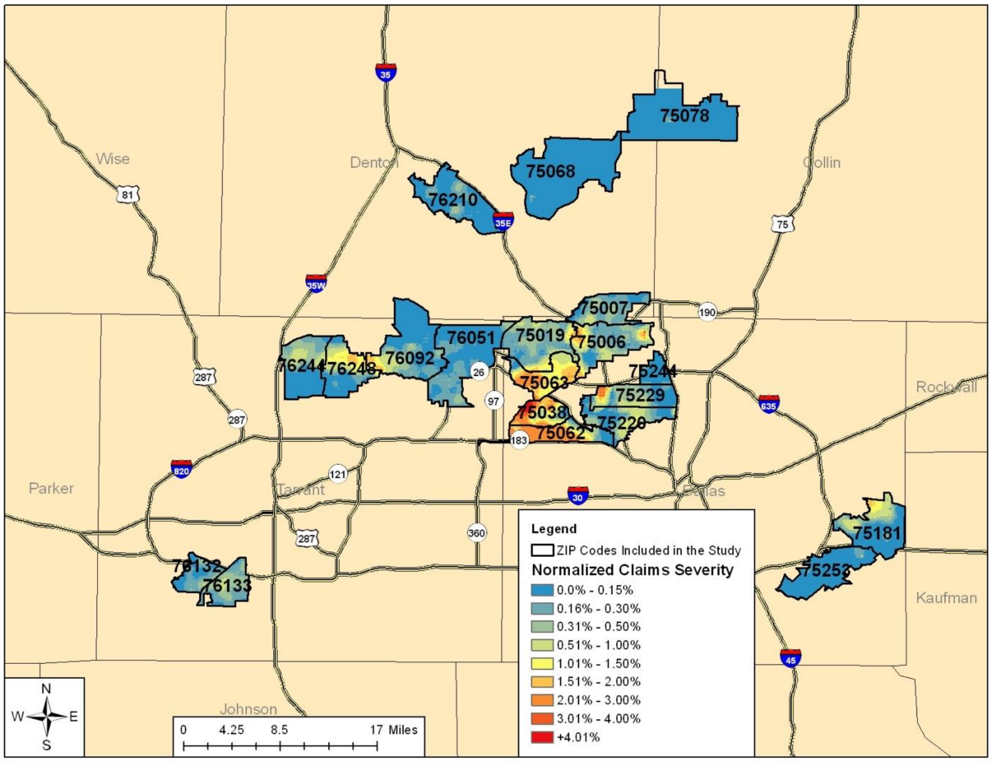

Figure 16: Spatial distribution of normalized average claim severity.

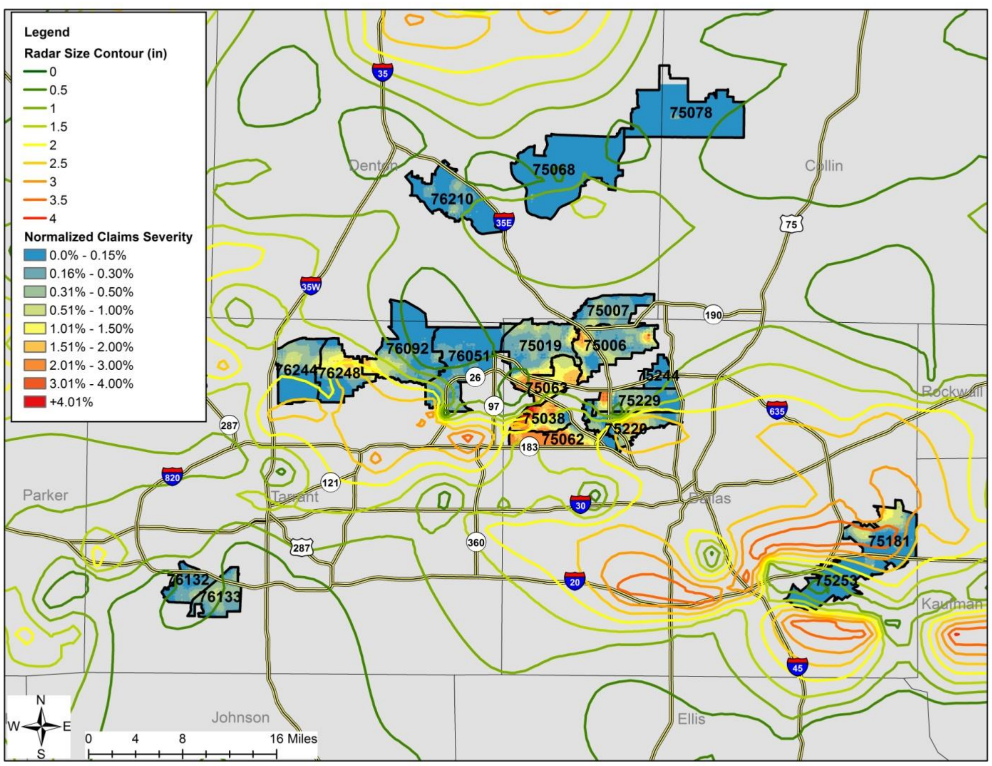

Figure 17: Spatial distribution of normalized average claim severity compared with contours of radar-indicated hail size.

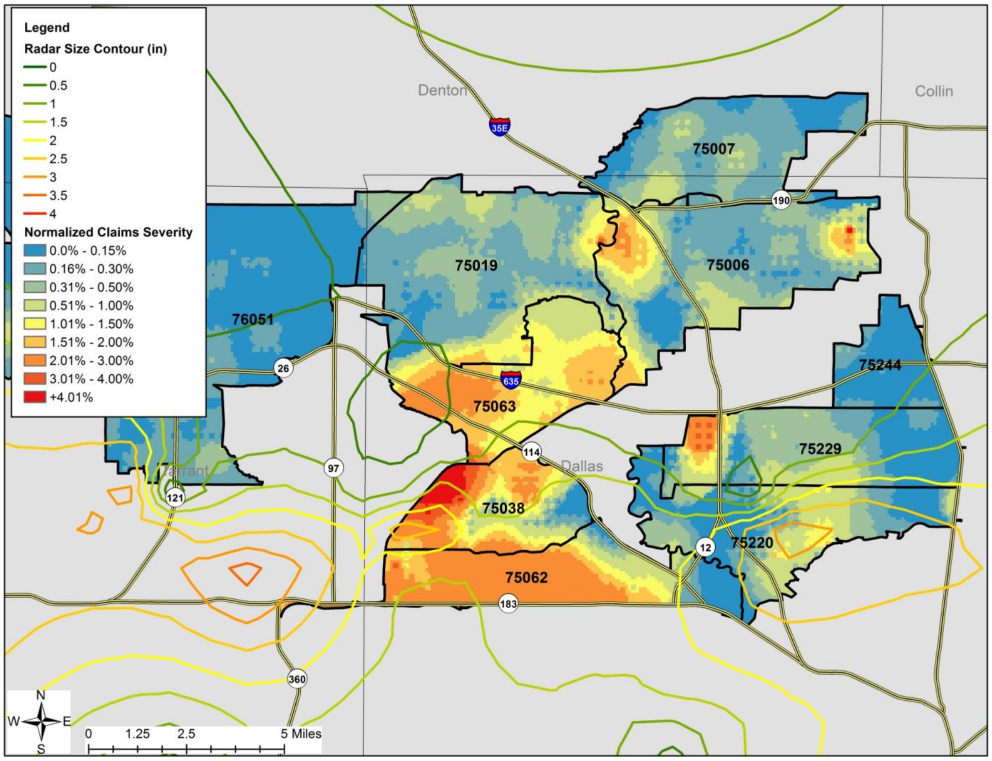

Figure 18: A detailed view of the spatial distribution of the highest normalized average claim severities in northwestern Dallas County.

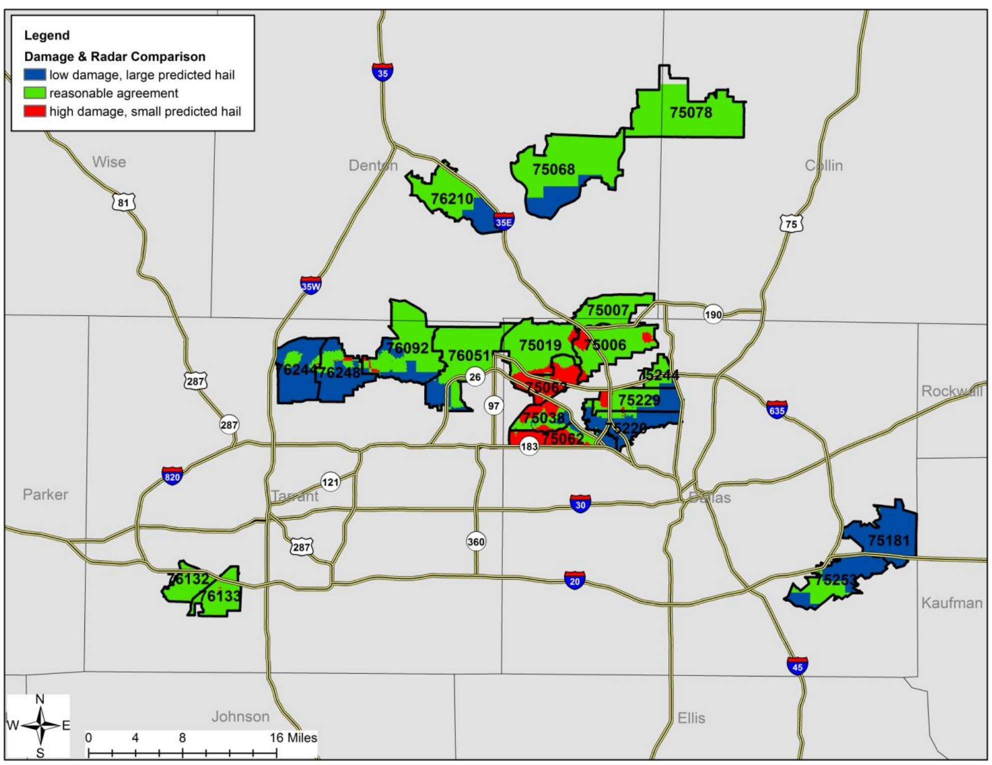

Figure 19: Comparison of correlation between damage severities and radar-estimated hail sizes.