3B.1 CLIMATOLOGY OF CLAIMS: THE INFLUENCE OF METEOROLOGICAL VS NON-METEOROLOGICAL FACTORS ON WIND & HAIL PROPERTY INSURANCE CLAIMS IN THE SOUTHEAST U.S.

Megan D. Walker[1] and Charles H. Paxton[2]
[1]Blue Skies Meteorological Services, Gainesville, FL and [2]Channelside Weather, Cocoa Beach, FL

1. INTRODUCTION

Florida accounts for 6.5% of the population, 9% of all homeowners' property insurance claims, and 79% of all lawsuits filed over such claims in the U.S. (Executive Office of the Governor, State of Florida, 2022).

Florida is a clear outlier among U.S. states in the proportion of insurance claims that are litigated, and the financial burden of that litigation has become a severe strain on the Florida property insurance marketplace. Average homeowners' insurance premiums have more than doubled over the past 3 years; several insurers have been declared insolvent; many more have stopped writing policies in Florida or are no longer insuring homes with older roofs; and the financial stability rating of nearly two dozen Florida insurers has been threatened with downgrade.

Research from the Florida Office of Insurance Regulation (OIR) indicates that Florida insurers are not disproportionately denying claims, but rather that a disproportionate number of denied claims are being litigated (Altmaier, 2021). The OIR has identified a number of legislative factors that incentivize expensive claims-related litigation. However, the relative contributions of meteorological and non-meteorological factors to the initial filing of weather-related property insurance claims is an issue that remains uninvestigated not just in Florida, but across the U.S.

2. METHODS

This deficit in knowledge of the drivers of weather-related property insurance claims is addressed by focusing on eight southern states with coastal exposure (Figure 1) and investigating the relationship between severe weather occurrence and weather-related property insurance claims.

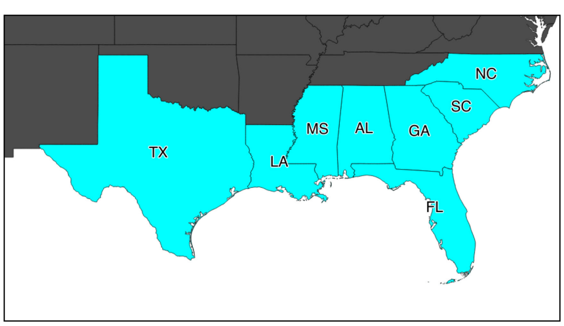


Figure 1: The study area consists of eight southern states with coastal exposure.

Corresponding author address: Megan D. Walker, Blue Skies Meteorological Services, Gainesville, FL; email: meganwr@blueskiesmeteorology.com

Seven of the eight states have a similar severe hail climatology: Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, and North Carolina. For simplicity, these seven states are hereafter referred to as the "southeastern states." The frequency of severe and significant severe hail is much higher in northern Texas, providing a contrasting climate with which to compare the robustness of the relationships between severe hail occurrence and hail-related claims (Figure 2).

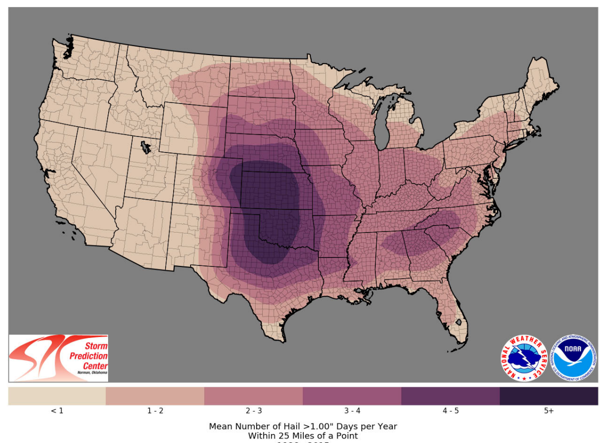


Figure 2: Mean number of days per year on which hail 1" diameter or larger was reported within 25 miles of a point, 1986 – 2015. Reprinted from "30-year Severe Weather Climatology," NOAA Storm Prediction Center, https://www.spc.noaa.gov/wcm/

We explore this relationship by comparing the frequency, seasonality, and severity of wind and hail events intense enough to cause property damage to the frequency, seasonality, and severity (cost) of property insurance claims associated with those perils. We also assess whether Florida is an outlier in any aspect of that relationship when considered in the context of regional variability.

In the absence of non-meteorological factors, we expect locations with more frequent and more intense severe weather events to have more and costlier weather-related (wind and hail) insurance claims. Where that is not case – where, for example, milder weather is associated with a higher proportion of insurance claims – we know that other factors are at play.

Non-meteorological factors considered in this analysis include population, state land area, population density, urbanization, the owner-occupied housing rate, and median home cost. These demographic data were sourced from the U.S. Census Bureau QuickFacts for the most recent year available (United States Census Bureau, 2020). Table 1 shows the value of these metrics for each state in the study area.

Throughout this analysis, the linear correlations between claims and meteorological and non-meteorological factors are expressed as the Pearson bivariate correlation coefficient, r.

Non-Meteorological Characteristics of States							
State	Population	Area (mi^2)	Population Density (ppl/mi^2)	Housing Units	Owner-Occupied Housing Unit Rate	Median Value of owner-occupied housing units	% of Population in Urban Areas, 2010
AL	5,039,877	50,647	99.2	2,313,642	69.2%	$ 149,600	59.0%
FL	21,781,128	53,652	401.4	10,054,457	66.2%	$ 232,000	91.2%
GA	10,799,566	57,717	185.6	4,475,274	64.0%	$ 190,200	75.1%
LA	4,624,047	43,210	107.8	2,093,393	66.6%	$ 168,100	73.2%
MS	2,949,965	46,924	63.1	1,332,050	68.8%	$ 125,500	49.4%
NC	10,551,162	48,623	214.7	4,801,712	65.7%	$ 182,100	66.1%
SC	5,190,705	30,064	170.3	2,395,943	70.1%	$ 170,100	66.3%
TX	29,527,941	261,268	111.6	11,869,072	62.3%	$ 187,200	84.7%

Sources: US Census, most recent year available (2020 and 2021), except where marked otherwise

Table 1: Demographic, socioeconomic, and geographic characteristics of states within the study area. Data are for the most recent year available from the U.S. Census Bureau. For most categories, this is 2020 or 2021. Urbanization data are from 2010 and were sourced from Iowa State University's Iowa Community Indicators Program, based on U.S. Census data.

2.1 Data

The climatology of severe weather events is assessed via National Weather Service Storm Data (National Weather Service, 2021), accessed via the National Centers for Environmental Information (NCEI) Storm Events Database (SED). To align with National Weather Service (NWS) severe hail criteria as well as with research on the sizes of hail that cause damage to common roofing materials (e.g. Marshall, et al., 2002), hail 1" diameter or larger was considered as potentially capable of causing roof damage.

Claims data were provided by LexisNexis® Risk Solutions, whose database contains claims information contributed by U.S. insurers. LexisNexis estimates they capture 97% of U.S. claims. LexisNexis provided aggregated, depersonalized wind and hail claims data by state, month, and year during the period 2007 - 2021. These data are similar to those utilized in their Annual Home Insurance Trends Report (LexisNexis Risk Solutions, 2021).

Our study period spans 15 years between 2007 and 2021. Although hail data were available for a full, standard 30-year climate period, claims data were only available through 2007. The study period is therefore limited to the period of overlap between these two data sources.

3. RESULTS: HAIL

3.1 Overview

During the 15-year study period, NCEI's Storm Events Database records more than 26,000 reports of hail 1" diameter or larger in the eight state region (Figure 3). The majority of hail reports in the southeastern states were marginally severe 1" hail, while, as expected, Texas had a higher proportion of hail larger than 1" diameter. Florida had the fewest severe hail reports in the region, with 1007 reports, or 3.86% of the regional total. Texas had by far the most severe hail reports, with 14,010, or 53.65% of the regional total.

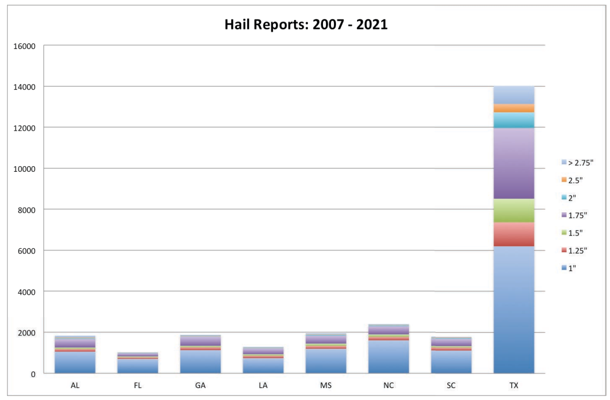


Figure 3: Total severe hail reports during the period 2007 – 2021, by state.

During this same period, insurers reported more than 4.6 million claims for hail-related damage to LexisNexis (Figure 4). Mississippi had the fewest hail claims in the region, with 100,441, or 2.18% of the regional total. Unsurprisingly, Texas had the most hail claims, with 2.76 million, or 60.03% of the regional total.

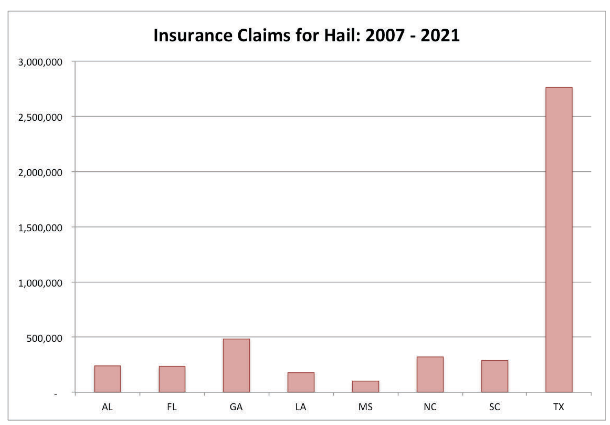


Figure 4: Total insurance claims for hail damage during the period 2007 – 2021, by state.

Due to the outsize number of both hail reports and hail claims in Texas relative to the other seven states in this study, comparing the raw number of hail claims to hail reports creates the appearance of a strong positive correlation (Figure 5, top panel). However, focusing only on the seven southeastern states reveals substantial variability and little direct correlation between hail claims and hail reports (Figure 5, bottom panel).

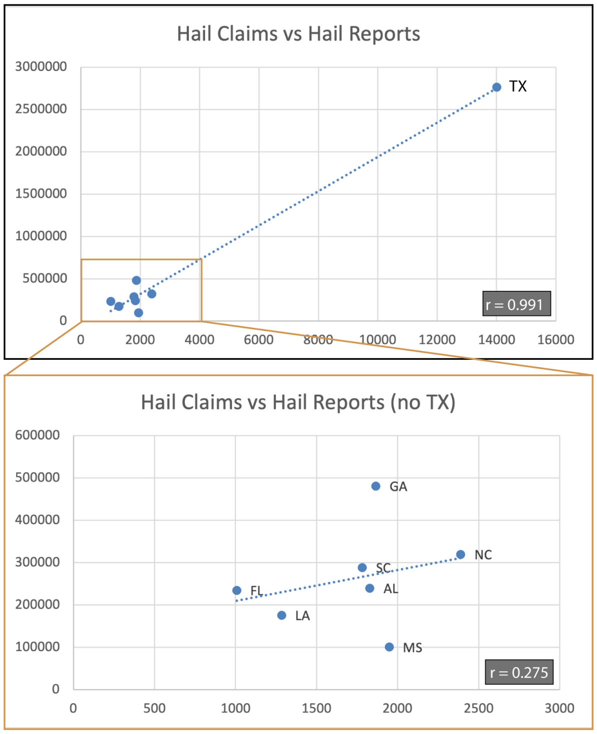


Figure 5: Hail claims vs. severe hail reports (1" or larger) during the period 2007 – 2021. Top panel: all 8 states. Bottom panel: 7 southeastern states only. The linear correlation between hail claims and hail reports drops dramatically when data from Texas are excluded (bottom panel).

The hail claims and hail reports data were therefore normalized by examining the ratio of hail claims to hail reports (i.e. the number of hail claims per hail report) in each state. We find significant variability in this metric. Summed over the entire 15-year study period, the number of insurance hail claims per severe hail report (1" diameter or larger) varied by a factor of 5 across the 8-state region: from a low of 52 hail claims per report in Mississippi to 258 claims per report in Georgia (Figure 6).

We also explored normalizing the data by considering the differential burden of hail claims and hail reports in each state. The claim burden was calculated as the fraction of all regional hail claims filed in each state, while the report burden was calculated as the fraction of all regional hail reports recorded in each state. Figure 7 shows the claim burden (red bars), the report burden (blue bars), and the differential burden for each state (purple bars). The differential burden is calculated as (claims burden) – (report burden).

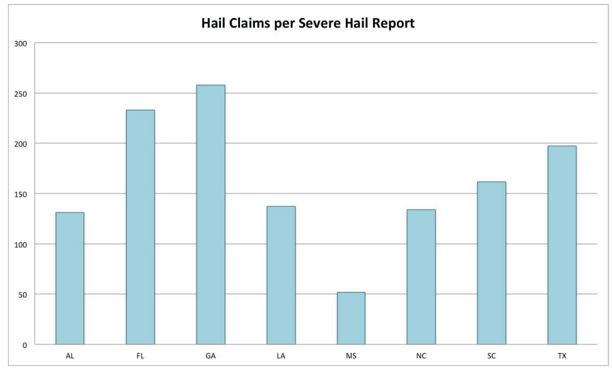


Figure 6: The average number of hail claims per severe hail report (1" or larger) filed during the period 2007 – 2021, by state.

The states with positive differential burdens (Texas, Georgia, and Florida) are those with a higher fraction of regional hail claims than regional hail reports. These states also have the highest number of hail claims per report (see Figure 6).

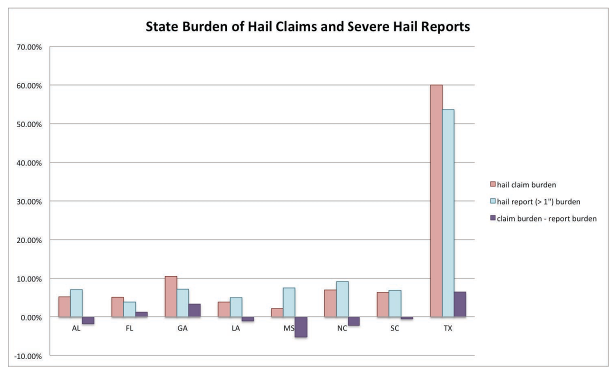


Figure 7: The fraction of total regional hail claims (red bars) and severe hail reports (blue bars) reported in each state during the 15-year study period. The difference between the claim burden and report burden is shown by the purple bars.

These two different methods of normalization provide similar explanatory power. We therefore proceeded with the simpler claims-per-report metric throughout our analysis to explore seasonal and annual relationships between hail claims and meteorological and non-meteorological variables.

3.2 Seasonal Relationships

To explore the seasonal relationship between hail claims and hail reports, we examined monthly claims and reports, summed over the entire 15-year period, both for the region as a whole as well as for each state individually. Figure 8 shows the number of hail claims and hail reports during each month, summed over the entire 8-state region.

Both claims and reports peak during spring and early summer (March – June), with a small secondary peak during October. The strong seasonal correlation (r = 0.92) between claims and reports evident in Figure 8 suggests that hail claims are generally reported soon after hail occurrence; they do not appear to be a consistently lagging indicator.

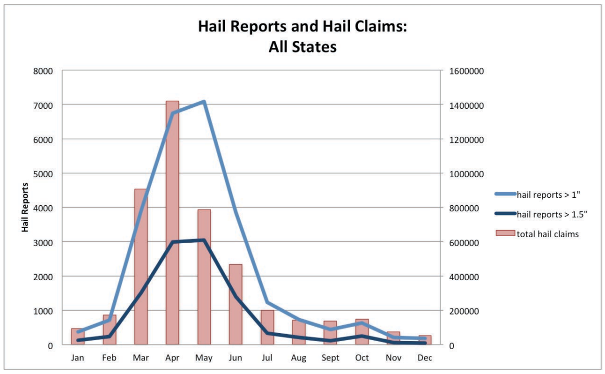


Figure 8: Monthly hail claims (red bars) and hail reports (blue lines), summed over all 8 states and all 15 years of the study period.

All states in the study region show a moderate to strong correlation between monthly hail claims and monthly hail reports (Table 2), with correlation coefficients ranging from a low of 0.76 in Florida and Mississippi to a high of 0.96 in Louisiana. Figure 9 illustrates the variability in the seasonal relationship between claims and reports across individual states.

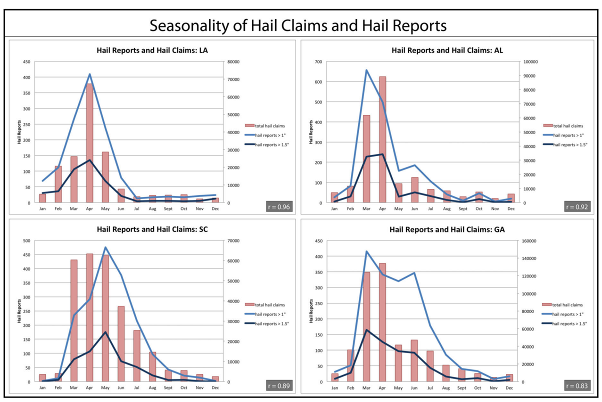


Figure 9: As in Figure 8, but for individual states rather than the study region as a whole.

Seasonal Correlation between Hail Claims and Hail Reports	
State	Pearson's r
AL	0.92
FL	0.76
GA	0.83
LA	0.96
MS	0.76
NC	0.83
SC	0.89
TX	0.90
All States	0.92

Table 2: Pearson's coefficients (r) describing the correlation between monthly hail claims and monthly hail reports for each state during the study period.

The two states with the lowest correlation coefficient between monthly claims and reports – Florida and Mississippi – highlight the strong influence of individual high-impact hail events on these data. Both Florida and Mississippi have large peaks in hail claims in March without a correspondingly sharp peak in hail reports (Figure 11), indicating one or more hail events that produced substantial insured losses that did not scale with the number of hail reports describing the event(s).

The interpretation of this observation is discussed in the following section, 3.3 Catastrophe Claims.

3.3 Catastrophe Claims

Catastrophe claims are those associated with a single weather event that produces large, widespread losses. The percent of hail claims attributable to catastrophe events varies by state from a low of 39% in Florida to a high of 73% in Texas (Figure 10).

We hypothesized that catastrophe claims would be associated with more hail claims per hail report but found that the opposite was true when considering the study period as a whole (Figure 10). States in which catastrophe claims comprise a higher fraction of total hail claims (e.g TX) tend to have a *lower* average number of hail claims per hail report. This negative correlation is strongest for larger hail sizes, with a correlation coefficient of r = -0.82 describing the relationship between the fraction of all claims that are associated with a catastrophe event and the number of hail claims per report of hail 1.5" diameter or larger.

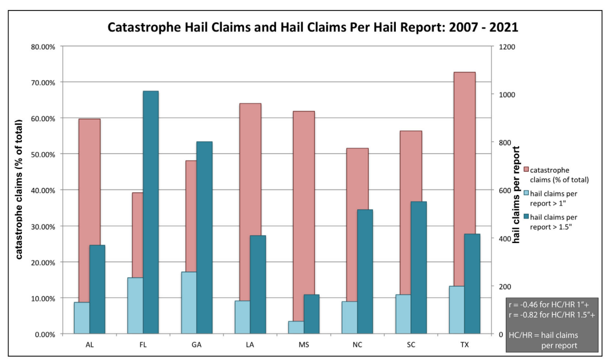


Figure 10: Comparison of the fraction of claims attributable to catastrophe events (red bars) with the number of hail claims per hail report over the entire study period (teal bars).

However, as mentioned in the previous section, individual high-impact (catastrophe) events can produce widespread damage and a large increase in the number of hail claims. These events result in an outsize number of hail claims relative to the number of reports captured in the Storm Events Database. In other words, such events result in significant temporary increases in the number of hail claims per hail report, which correspond with temporary increases in the fraction of hail claims attributable to the catastrophe event.

The data from Florida and Mississippi in March clearly illustrate this point. In both states, there is a sharp peak in claims in March, out of proportion with the peak in reports (Figure 11, left column). When we examine the annual time series of March hail claims and reports (Figure 11, right column), we find the source of the peaks: a dramatic peak in claims in Florida in March of 2018 and 2019, and in Mississippi in March of 2013 and 2020 (Figure 11, right column).

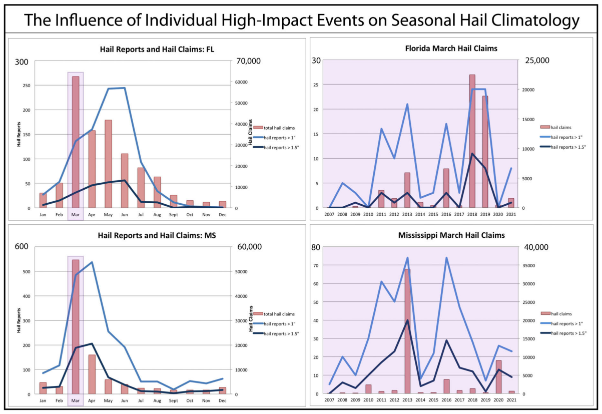


Figure 11: 4-panel graphic showing the influence of individual high-impact hail events on the seasonal relationship between hail claims and hail reports. The left column shows monthly hail claims and hail reports, while the right column shows the annual time series of March hail claims and reports. Data for Florida are shown on the top row, while data for Mississippi are shown on the bottom row. Both Florida and Mississippi have a sharp peak in hail claims during the month of March.

In Florida, severe thunderstorms on 20 March 2018 and 27 March 2019 produced hail up to 2" diameter in densely populated areas of the state, including communities in and around Jacksonville, Orlando, Daytona Beach, Cocoa, Cape Canaveral, and Melbourne (Figure 15).

These events are captured in the Storm Events Database in 24 reports of severe hail in both March of 2018 and March of 2019. In response to these severe hail events, there were 22,460 hail claims in Florida during March of 2018 and 18,876 such claims in March of 2019 (Figure 11, top right panel). These claims resulted in $369 million and $317 million in insured losses, respectively.

Florida's average number of hail claims per hail report, calculated over the entire 15-year period, is 233 (Figure 6). However, during March of 2018 and March of 2019, the number of hail claims per hail report jumped to 936 and 787, respectively. During those same months, over 83% of all hail claims were associated with a catastrophe event, far above the 39% that is the average for the 15-year period.

Figure 12 shows the fraction of all hail claims associated with a catastrophe event (red line) as well as the number of hail claims per severe hail report (teal bars) during the month of March for each year during the study period in the state of Florida. The correlation between these two metrics is moderately strong, with r = 0.79, suggesting that the expected relationship of catastrophe events producing more hail claims per hail report does indeed hold true for individual, high-impact events like those that impacted Florida in March of 2018 and 2019.

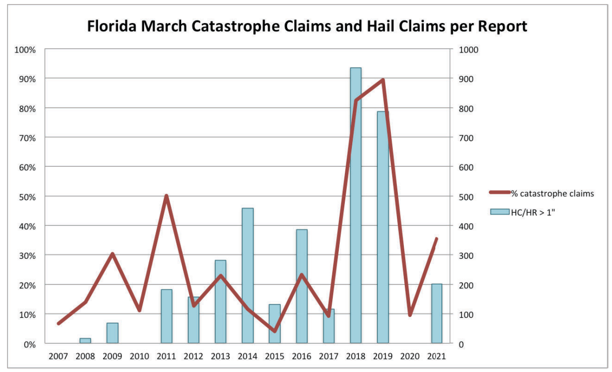


Figure 12: Comparison of the fraction of all hail claims attributable catastrophe events (red line) with the number of hail claims per severe hail report (teal bars) in March of each year in Florida. HC/HR = hail claims per hail report.

We see a similar relationship between catastrophe hail claims and the number of hail claims per report in Mississippi in the month of March, with sharp peaks in both metrics in 2013 and 2020 (Figure 13). During March of both of these years, severe thunderstorms produced large hail in populated regions, including the city of Jackson (Figure 16). The correlation between the fraction of hail claims associated with a catastrophe event and the number of hail claims per hail report during the month of March for each year of the study period was similar to that in Florida, with r = 0.75.

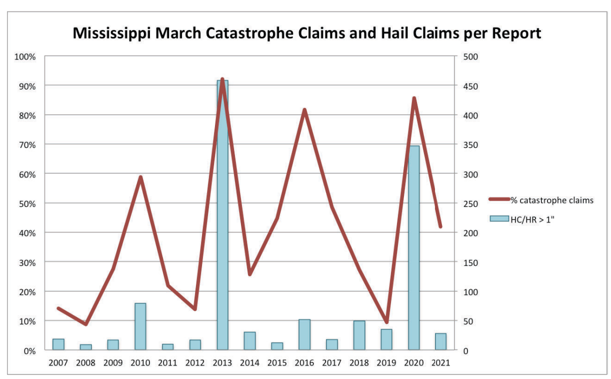


Figure 13: Comparison of the fraction of all hail claims attributable catastrophe events (red line) with the number of hail claims per severe hail report (teal bars) in March of each year in Mississippi. HC/HR = hail claims per report.

The analysis of March hail claims and hail reports in Florida and Mississippi indicates a positive underlying relationship between catastrophe claims and the number of claims per report during individual events. However, when averaged over a longer period of time and a larger area, that positive correlation is subsumed in the data by the fact that Storm Data are geared toward climatology rather than societal impacts. The purpose of the Storm Events Database is to record the location and magnitude of severe storm events, regardless of the number of people or properties impacted.

Since the majority of the study area is rural (tan areas in Figure 14) and therefore has a low population density, the majority of hail falls in locations without much property to damage, resulting in few hail claims per hail report. On the other hand, claims tend to be concentrated in urban areas, which are also the locations that, when impacted by severe weather, tend to result in losses that meet the insurance definition of a "catastrophe."

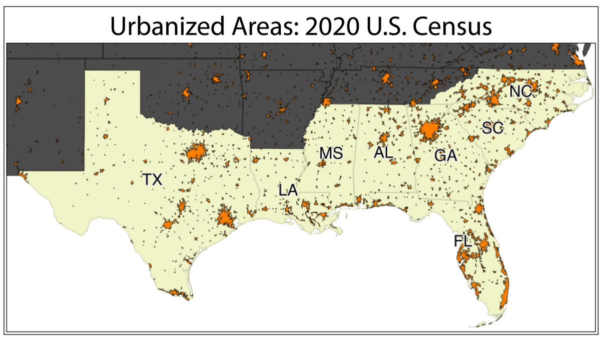


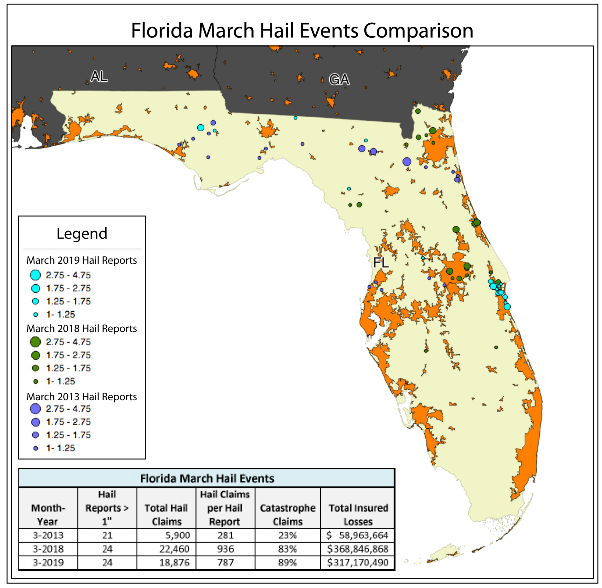
Figure 14: Urbanized areas, in orange. Source: U.S. Census Bureau, 2020, TIGER/Line® Shapefiles: Urban Areas

Figures 15 and 16 illustrate the strong influence of hail location on the number of claims and the proportion of those claims that are attributable to a catastrophe event.

Figure 15 shows the locations of hail reports in Florida during March in the years 2013, 2018, and 2019. Urban areas are shaded in orange, according to 2020 U.S. Census data. The inset table characterizes these months with the number of hail reports and hail claims, the number of hail claims per report, the percent of all claims attributable to a catastrophe event, and the total insured losses.

In 2013, Florida had 21 reports of severe hail, compared with 24 such reports in 2018 and 2019. However, whereas 2018 and 2019 saw approximately 20,000 claims and over $315 million in insured losses each, less than 6000 claims were filed in 2013, with insured losses of less than $59 million. In March 2018 and 2019, more than 80% of all claims were attributable to a catastrophe event, whereas less than 25% were in 2013.

What was different in 2013? Why, with nearly the same number of hail reports, were claims, losses, and the fraction of catastrophe claims so much lower? Location: large hail impacted mostly rural areas in northern Florida in 2013 (purple circles in Figure 15), whereas large hail in 2018 (green circles) and 2019 (teal circles) impacted densely populated urban areas.



Month-Year	Hail Reports > 1"	Total Hail Claims	Hail Claims per Hail Report	Catastrophe Claims	Total Insured Losses
3-2013	21	5,900	281	23%	$ 58,963,664
3-2018	24	22,460	936	83%	$368,846,868
3-2019	24	18,876	787	89%	$317,170,490

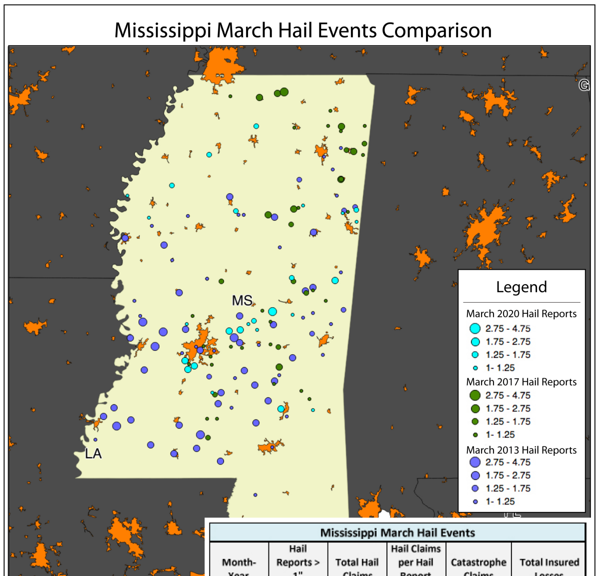
Figure 15: Comparison of hail events (hail sizes and locations) and associated claims in Florida during March of 2013, 2018, and 2019.

The influence of hail location is seen even more dramatically in Mississippi when comparing hail reports and hail claims in March 2020 to those in March 2017 (Figure 16). In 2020, Mississippi had 26 reports of severe hail (teal circles) compared with 47 such reports in 2017 (green circles). However, despite having nearly twice as many hail reports in 2017, there were less than 10% as many hail claims in 2017 as in 2020 (Figure 16, inset table).

The relevant difference between these two months is once again the locations in which severe hail fell. Although 2020 saw fewer hail reports, much of the large hail impacted populated southern Jackson, MS, whereas in 2017, the largest hail was concentrated in rural northeastern Mississippi.

The seasonally coincident rise and fall of claims and reports across all 8 states examined in this study suggests that storm data generally capture the timing and location of hail large enough to cause property damage (Figure 8 and Table 2). However, as illustrated in Figures 12 and 13, storm reports of hail do not necessarily scale linearly with the impact of those events, especially when the events impact densely populated areas.

This is not a critique of Storm Data: as previously mentioned, that database is designed to capture the location and magnitude of damaging weather, not directly estimate its societal impact. Understanding the societal impact of severe hail requires examination on a finer spatial scale that accounts explicitly for variations in population distribution and density.



Mississippi March Hail Events					
Month-Year	Hail Reports > 1"	Total Hail Claims	Hail Claims per Hail Report	Catastrophe Claims	Total Insured Losses
3-2013	74	33,899	458	92%	$246,022,005
3-2017	47	834	18	49%	$ 5,344,631
3-2020	26	9,022	347	86%	$103,680,555

Figure 16: Comparison of hail events (hail sizes and locations) and associated claims in Mississippi during March of 2013, 2017, and 2020.

3.4 Interannual Trends

Across the study region, we find a trend toward an increasing number of hail claims per hail report over the 15-year study period (Figure 17). This trend is possibly due in part to population growth. However population growth is insufficient to explain the growth in the number of hail claims per report. While the population of the 8-state region grew by 17% from 2007 – 2021, the number of hail claims per hail report increased by 78% (linear trend).

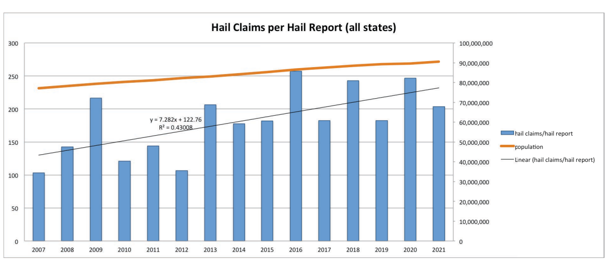


Figure 17: Comparison of the number of hail claims per hail report summed over all states for each year in the study period (blue bars) with the population of the study region (orange line). A linear best-fit trend line is shown in black.

In fact, in all 8 states, the trend is toward an increase in the number of hail claims per report over time. The increase in claims-per-report outpaces population growth in all states but Georgia. There is strong variability in the strength of this trend, ranging from weak in TX and AL (Figure 18, upper left and lower left panels, respectively) to quite strong in FL and SC (Figure 18, upper right and lower right panels, respectively).

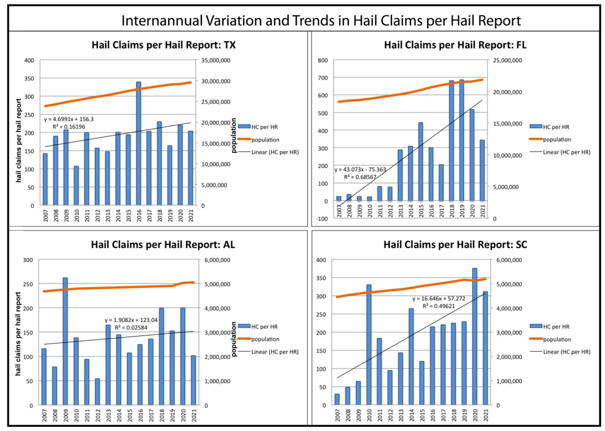


Figure 18: Hail claims per hail report (blue bars) in four states within the study region, illustrating interannual variation and trends relative to population growth (orange line). HC per HR = hail claims per hail report.

Florida has the fastest growth in hail claims per report of any state in the study area (Figure 18, upper right panel). The number of claims per report has grown 4 times faster in Florida than in the state with the next highest growth rate (South Carolina, bottom right panel in Figure 18). During the 15-year period from 2007 – 2021, Florida's population increased by 19% while the number of hail claims per hail report increased by more than 1300% (linear trend).

3.5 Claim Denial Rate

This research finds that over the study period, hail claims are not significantly more likely to be denied in states with a high claims-per-report ratio (i.e. that "under-report" hail or "over-claim" damage), although the correlation between the claim denial rate and the number of claims per report does increase for larger hail sizes (Figure 19). For hail 1.5" and larger, variation in the number of claims per report (dark teal bars in Figure 19) explains 47% of the variation in the claim denial rate (r = 0.684).

At 25%, Florida's claim denial rate for the study period is the highest in the region, but it is not substantially higher than the next highest state (Louisiana, with a claim denial rate of 23%). The state with the lowest claim denial rate is Alabama, in which less than 15% of claims were denied during 2007- 2021.

These data indicate that Florida's disproportionate burden of litigation is not due to a disproportionate (and meteorologically unjustified) denial of claims. In other words, Florida insurers do not appear to be disproportionately denying claims at a rate sufficient to explain the excess litigation. Florida's claim denial rate is marginally higher than the next highest state

(Louisiana), but Florida's litigation rate is twenty times higher than the next highest state (Altmaier, 2021).

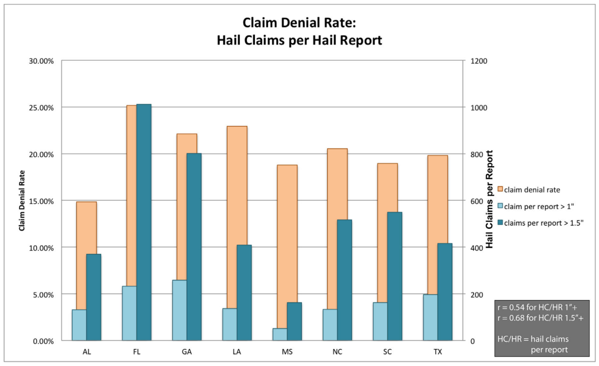


Figure 19: Comparison of the state-average hail claim denial rate (orange bars) to the number of hail claims per hail report over the entire study period (teal bars).

Although Florida has the highest claim denial rate of the region averaged over the study period, there has been no upward trend over time in the claim denial rate even as the number of hail claims per report have increased dramatically in the state (Figure 20), indicating that insurers have not been more likely to deny claims despite the dramatic increase in hail claims which has not coincided with an increase in the reported occurrence of severe hail.

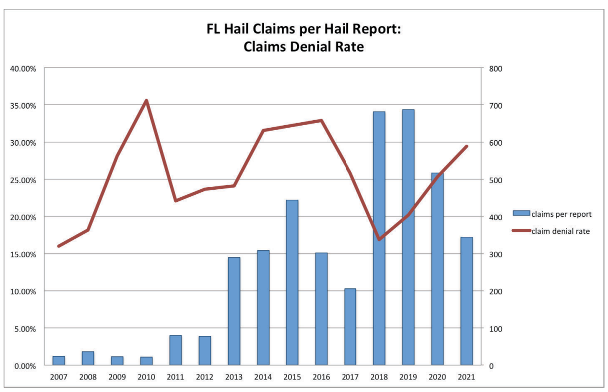


Figure 20: Comparison of the annual number of hail claims per hail report (blue bars) and the claim denial rate (red line) in Florida.

3.6 Hail Claim Costs

Over the study period, we find that hail claims are not generally more costly in states with more large hail per square mile (Figure 21). In fact, the correlations between average claim cost and reports of hail per square mile are negative for hail 1" or larger as well as the subset of hail 1.5" or larger (r = -0.603 and r = -0.397, respectively).

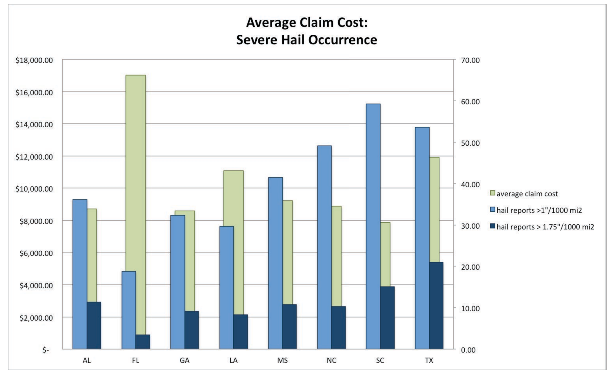


Figure 21: Comparison of the state average hail claim cost (green bars) to the number of hail reports per 1000 square miles for two size categories (blue bars) over the entire study period.

Florida has the highest average cost per claim but the lowest density of severe hail occurrence in the study region. Average claim costs in Florida have been approximately 2 times higher than in other states since at least 2007 (Figure 22), suggesting a higher baseline cost. This higher baseline cost may be due in part to Florida's strict building codes, developed in response to the state's hurricane risk.

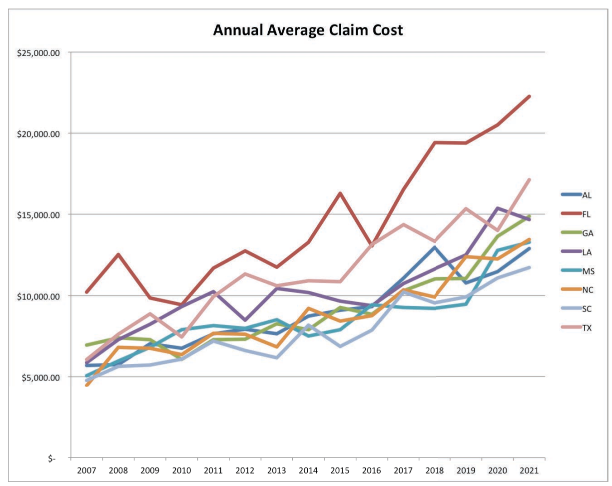


Figure 22: State average annual claim costs during the study period.

In all states, the average claim cost has more than doubled since 2007, a rate of growth that is two to three times higher than the growth in the construction price index (Figure 23). Although Florida's average claims costs are the highest in the region, those costs are not growing faster than in Florida than in neighboring states. In other words, the data do not show anomalously high claims cost inflation in Florida relative to other states in the region.

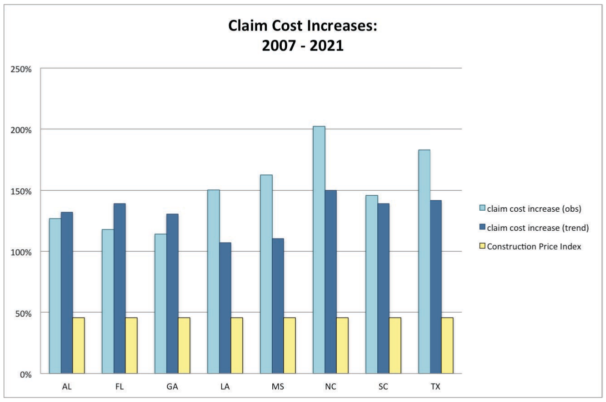


Figure 23: Increases in the average claim cost in each state from 2007 – 2021. The growth rate is calculated as the increase in cost from 2007 to 2021 relative to the cost in 2007 and is calculated both from the observed data (light blue bars) as well as from the linear trend (dark blue bars). The increase in the national Fisher Construction Price Index, a proxy for construction and repair costs, is shown yellow.

3.7 Correlations with Non-Meteorological Factors

To explain the observed variability in the claims data and storm data, we looked for additional relationships with non-meteorological factors.

We found that correlations with socioeconomic and demographic factors generally decreased when data from Texas were excluded, for the reasons mentioned at the beginning of this paper. For some variables, the correlations reversed direction, from positive to negative.

For example, we found that the number of hail reports as well as the density of those reports per square mile were positively correlated with both population and state land area when the data from Texas were included. However, when the data from Texas were excluded, the correlations became moderately negative. We also find that, when Texas is excluded, the total number of claims per state is only weakly correlated with the total population and average population density of that state.

The correlation matrices for meteorological and non-meteorological variables are shown in Tables 3 and 4. Pearson's bivariate correlations were calculated using hail claims and hail report data summed over the entire 15-year study period. Table 3 shows these correlations calculated with data that include Texas, while the correlations in Table 4 were calculated with data that do not include Texas.

Although we did not find particularly strong correlations with demographic and socioeconomic variables on a state level in this study, our analysis of individual high-impact catastrophe events suggests that such relationships do exist, and an analysis on a finer spatial scale (e.g. by county or census block) may reveal more consistent relationships not apparent on the state level.

Correlations between Meteorological and Non-Meteorological Factors (All States)

	State Population	State Area	State Population Density (ppl/mi2)	Number of Housing Units	Owner-Occupied Housing Unit Rate	Median Value of Owner-Occupied Housing Units	Fraction of Population in Urban Areas, 2010	Total Number of Hail Claims	Number of Approved Hail Claims	Average Cost of Approved Claims	Number of Hail Reports 1" or larger	Number of Hail Reports 1" or larger per mi^2	Number of Hail Reports 1.5" or larger	Number of Hail Reports 1.5" or larger per mi^2
State Population	1.00													
State Area	0.80	1.00												
State Population Density (ppl/mi2)	0.43	-0.19	1.00											
Number of Housing Units	0.99	0.74	0.51	1.00										
Owner-Occupied Housing Unit Rate	-0.77	-0.71	-0.17	-0.73	1.00									
Median Value of Owner-Occupied Housing Units	0.70	0.18	0.88	0.75	-0.54	1.00								
Fraction of Population in Urban Areas, 2010	0.82	0.45	0.67	0.84	-0.67	0.92	1.00							
Total Number of Hail Claims	0.79	0.99	-0.18	0.73	-0.70	0.21	0.46	1.00						
Number of Approved Hail Claims	0.79	0.99	-0.19	0.73	-0.70	0.20	0.45	1.00	1.00					
Average Cost of Approved Claims	0.65	0.24	0.69	0.71	-0.34	0.71	0.76	0.17	0.17	1.00				
Number of Hail Reports 1" or larger	0.74	0.99	-0.26	0.68	-0.65	0.10	0.36	0.99	0.99	0.13	1.00			
Number of Hail Reports 1" or larger per mi^2	-0.02	0.33	-0.46	-0.07	0.09	-0.37	-0.33	0.41	0.42	-0.60	0.47	1.00		
Number of Hail Reports 1.5" or larger	0.74	0.99	-0.26	0.68	-0.64	0.10	0.37	0.99	0.99	0.15	1.00	0.44	1.00	
Number of Hail Reports 1.5" or larger per mi^2	0.32	0.75	-0.57	0.24	-0.24	-0.29	-0.07	0.79	0.80	-0.36	0.83	0.84	0.82	1.00

Table 3: Correlation matrix for meteorological and non-meteorological factors, calculated using data from all 8 states included in the study area.

Correlations between Meteorological and Non-Meteorological Factors (TX Excluded)

	State Population	State Area	State Population Density (ppl/mi2)	Number of Housing Units	Owner-Occupied Housing Unit Rate	Median Value of Owner-Occupied Housing Units	Fraction of Population in Urban Areas, 2010	Total Number of Hail Claims	Number of Approved Hail Claims	Average Cost of Approved Claims	Number of Hail Reports 1" or larger	Number of Hail Reports 1" or larger per mi^2	Number of Hail Reports 1.5" or larger	Number of Hail Reports 1.5" or larger per mi^2
State Population	1.00													
State Area	0.50	1.00												
State Population Density (ppl/mi2)	0.97	0.29	1.00											
Number of Housing Units	1.00	0.47	0.98	1.00										
Owner-Occupied Housing Unit Rate	-0.55	-0.71	-0.42	-0.51	1.00									
Median Value of Owner-Occupied Housing Units	0.93	0.32	0.95	0.92	-0.58	1.00								
Fraction of Population in Urban Areas, 2010	0.85	0.29	0.86	0.85	-0.57	0.96	1.00							
Total Number of Hail Claims	0.31	0.32	0.29	0.27	-0.59	0.47	0.37	1.00						
Number of Approved Hail Claims	0.26	0.30	0.24	0.21	-0.54	0.41	0.31	1.00	1.00					
Average Cost of Approved Claims	0.80	0.33	0.77	0.82	-0.28	0.70	0.75	-0.25	-0.31	1.00				
Number of Hail Reports 1" or larger	-0.45	-0.05	-0.45	-0.46	0.04	-0.49	-0.68	0.28	0.32	-0.80	1.00			
Number of Hail Reports 1" or larger per mi^2	-0.57	-0.71	-0.42	-0.56	0.51	-0.48	-0.60	0.07	0.12	-0.77	0.71	1.00		
Number of Hail Reports 1.5" or larger	-0.70	-0.02	-0.75	-0.72	0.18	-0.73	-0.83	0.19	0.25	-0.92	0.88	0.60	1.00	
Number of Hail Reports 1.5" or larger per mi^2	-0.79	-0.69	-0.67	-0.78	0.61	-0.69	-0.75	0.01	0.07	-0.89	0.67	0.94	0.72	1.00

Table 4: Correlation matrix for meteorological and non-meteorological factors, calculated by excluding data from Texas.

4. RESULTS: THUNDERSTORM WIND EVENTS

We are in the process of performing a parallel analysis comparing wind-related insurance claims to thunderstorm wind gust and damage reports. The full analysis was unfortunately not complete in time for inclusion in this conference paper.

However, initial results indicate a strong seasonal correlation between severe thunderstorm wind reports and wind-related insurance claims (Figure 24). The strength of the correlation increases for higher-magnitude wind events (i.e. those more likely to cause structural damage), from a correlation coefficient of 0.69 between wind claims and wind reports 60 mph or greater to a correlation coefficient of 0.94 between wind claims and the subset of wind reports 80 mph or greater.

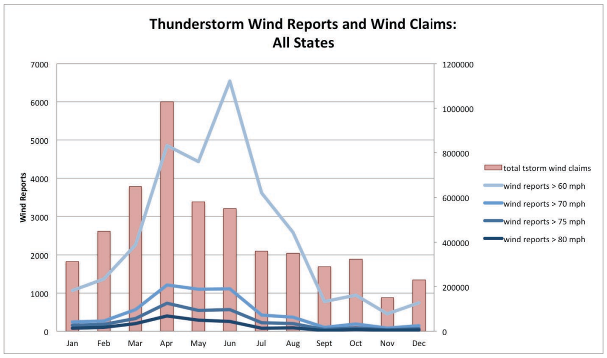


Figure 24: Monthly wind claims (red bars) and thunderstorm wind reports (blue lines), summed over all 8 states and all 15 years of the study period. The linear correlation between wind claims and wind reports increases for more intense wind events.

When examining all severe thunderstorm wind events (over 60 mph), the number of reports peaks in June, coinciding with the summer thunderstorm season along the southern coast. However, the peak in the strongest wind events occurs earlier, in April, suggesting that the strongest winds experienced in this region occur during organized springtime severe weather events associated with stronger dynamical forcing.

The initial wind analysis also indicates the cost inflation of wind claims has been similar to that of hail claims over the same period, with the regional-average wind claim cost increasing from $5,600 in 2007 to $13,600 in 2021, an increase of more than 140% (Figure 25). The total number of insurance claims for the region did not increase markedly during that time, although high claims numbers during a few years early in the study period (2008, 2009, and 2011) may obscure an underlying trend.

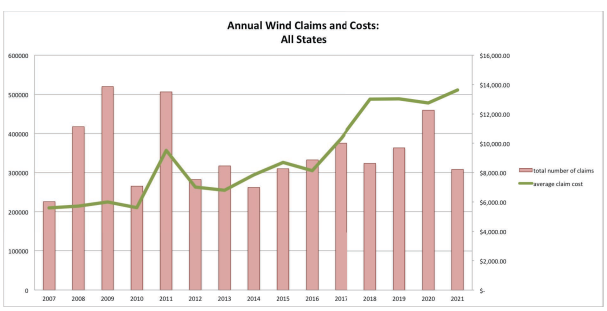


Figure 25: Regional-average annual claim costs during the study period (green line) and the number of wind-related insurance claims (red bars).

However, the number of wind claims per severe thunderstorm wind report (over 60 mph) did increase during the study period. The trend for the region as a whole was approximately half as strong for wind as for hail (Figure 26). Fitting a linear trend line to the data, the number of wind claims per severe thunderstorm wind report increased 33% from 2007 – 2021, while the number of hail claims per severe hail report increased 78% during the same period.

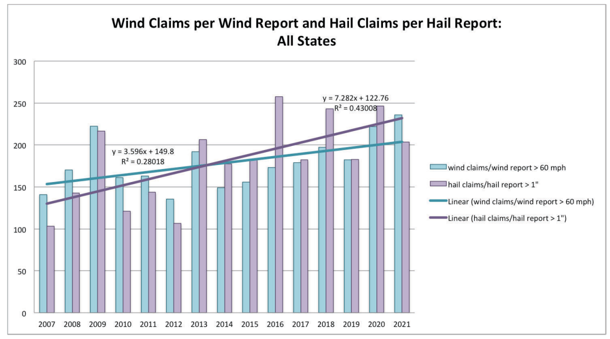


Figure 26: The number of wind claims per wind report over 60 mph, summed over all states for each year in the study period (teal bars), and number of hail claims per hail report over 1" diameter summed over all states for each year in the study period (purple bars). A linear trend line has been fitted to both variables.

We also found somewhat surprising consistency between the regional-average number of hail claims per severe hail report and the regional-average number of wind claims per severe thunderstorm wind report, with the number of hail claims per hail report ranging from 103 to 257 during the 15-year study period, and the number of wind claims per wind report ranging from 135 to 236 during that same period (Figure 26).

5. CONCLUSIONS

This analysis of the relationship between insurance claims for weather-related damage and reports of severe weather indicates that:

- Variation in hail reports is not sufficient to explain the variation in hail claims between states
- In all states, there are moderate to strong seasonal correlations between hail claims and hail reports
- There is substantial interannual variability in the number of hail claims and hail reports
- Individual, high-impact (catastrophe) events cause sharp increase in the number of hail claims without a correspondingly sharp increase in the number of hail reports
- Alone, the number and size of hail reports is not a reliable proxy for the societal impact of severe hail events – the locations and populations impacted must be taken into account
- All states show a trend toward an increasing number of hail claims per hail report; this trend outpaces population growth in all states but one
- Claims are not substantially more likely to be denied in states with more hail claims per severe hail report
- Average claim costs are not higher in states with more large hail reports per square mile
- Average claim costs have more than doubled in all states during the study period, far outpacing inflation

Returning to the questions about Florida's disproportionate burden of litigation that motivated this research, we find that Florida is not an outlier in terms of the seasonal relationship between hail claims and hail reports, the state-average claim denial rate, or the growth rate of average claims costs. However, the annual average number of hail claims per hail report has grown substantially faster in Florida than in any other state in the study region, far outpacing population growth.

In summary, this comparison of hail claims data with severe hail reports suggests that litigation in Florida is not being driven by a disproportionate denial of weather-related claims or due to a unique relationship between hail claims and hail reports in the state. In other words, the disproportionate litigation does not appear to stem from a dysfunction in the weather-related insurance claims adjusting process in Florida.

6. REFERENCES

Altmaier, David, 2021: Letter from the Commissioner of the Florida Office of Insurance Regulation to Blaise Ingoglia, Chair of the Florida Commerce Committee. Accessed 31 January 2023, https://www.floir.com/siteDocuments/ChairIngoglia04022021.pdf

Executive Office of the Governor, State of Florida, 2022: Proclamation calling on the Florida Legislature to hold a special session regarding property insurance. Accessed 31 January 2023, https://www.flgov.com/2022/04/26/calling-on-the-legislature-to-hold-a-special-session-regarding-property-insurance/

Iowa Community Indicators Program: Urban Percentage of the Population for States, Historical. Iowa State University. Available from https://www.icip.iastate.edu/tables/population/urban-pct-states

Marshall, Timothy P., et al., 2002: Hail Damage Threshold Sizes for Common Roofing Materials. 21st Conference on Severe Local Storms.

National Weather Service, 2021: Instruction 10-1605, Storm Data Preparation. Accessed 31 January 2023, https://www.nws.noaa.gov/directives/sym/pd01016005curr.pdf

United States Census Bureau, 2020: Quick Facts. Available from https://www.census.gov/quickfacts/fact/table/US/PST045222

LexisNexis Risk Solutions, 2021: Home Insurance Trends Report. Available from https://risk.lexisnexis.com/insights-resources/white-paper/2021-home-trends-report