Update to Touchstone Loss Estimates

Version 2022 Technical Update

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Revision History

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1 Executive Summary

Verisk Severe Thunderstorm Model for the United States

The Verisk Severe Thunderstorm Model for the United States incorporates new scientific research and a significant amount of additional hazard and loss data. The historical and stochastic catalogs have been updated. The event generation module uses a new detrending methodology for both hail and straight-line wind, as well as a new derecho detection algorithm. Local hail intensity calculations have been refined using a new spatially-varying intra-swath hail intensity methodology. The damage estimation module includes an innovative, component-based hail vulnerability framework, regional building code enhancements and enforcement practices (current as of 2020), and updated damage functions that explicitly incorporate local building characteristics. The updated model includes 100 new construction classes and 2 new occupancy classes. It expands support for several specialty lines of business, including marine lines, wind turbines, greenhouses, and heavy construction/infrastructure risks. The updated model includes new and enhanced secondary risk characteristics (SRCs), including roof year built, which explicitly accounts for roof upgrades (current as of 2020).

2 The Verisk Severe Thunderstorm Model for the United States

2.1 Model Updates and Changes

The June 2022 release of the Verisk Severe Thunderstorm Model for the United States includes new and updated features that:

- Represent a true "all-events" model that reflects the near-present climate and risk for all severe thunderstorm events, including a wide range of smaller, high-frequency to larger, low-frequency events
- Incorporate a new hazard detrending methodology
- Use a new granular approach to modeling hail intensity by allowing intensity to vary within a given hail footprint (i.e., "intra-swath hail intensity variation")
- Improve hail event footprints (length, width, and intensity probability distributions) using detailed radar reflectivity data run through an enhanced storm-tracking algorithm
- Incorporate a significant amount of new hazard data, including 7 additional years of storm reports and atmospheric reanalyses for all three modeled sub-perils and 20 years of detailed radar data for the hail sub-peril
- Include a new derecho detection algorithm
- Incorporate a significant amount of additional company claims, industry loss, building code enforcement, replacement cost, and roof age data as well as insights from in-house and published engineering studies
- Use a new innovative component-based approach to modeling hail vulnerability within an updated hail damage framework
- Account for building code evolution, adoption, and enforcement through updated wind and tornado damage frameworks, and extend building code assumptions to the hail damage framework
- Provide updated hail, straight-line wind, and tornado damage functions and/or distributions for residential and commercial structures, manufactured homes, automobiles, industrial facilities, marine, and infrastructure risks
- Expand support for several specialty lines of business, including wind turbines, greenhouses, marine risks (inland transit, marine hull, and marine cargo, among others), and heavy construction/infrastructure risks

- Expand support for secondary risk characteristics (SRCs), including the explicit use of gross area or square footage and other SRCs (e.g., roof geometry, cover, and pitch) to define hail vulnerability of traditional residential, commercial, and industrial risks
- Incorporate roof age and building code enhancements (current as of 2020), both spatially and temporally

2.2 Catalogs and Event Sets

Historical Catalog

The Verisk Severe Thunderstorm Model for the United States historical catalog of severe thunderstorm events used to build the model has been updated with up to seven years of additional available data since the last model update. Data sources include the:

- National Oceanic and Atmospheric Administration's (NOAA's) Storm Prediction Center (SPC)
- NOAA's National Centers for Environmental Information (NCEI)
- NOAA's National Centers for Environmental Prediction (NCEP)
- Community Collaborative Rain, Hail, and Snow (CoCoRaHS) Network
- Severe Hazards Analysis and Verification (SHAVE) Project
- Climate Forecast System Reanalysis (CFSR)
- NOAA's Next Generation Radar (NEXRAD) Level II and III Data

Marquee/Historical Event Set

The Verisk Severe Thunderstorm Model for the United States includes a marquee event set consisting of 5 perturbations of 7 events, for a total of 35 events. While the historical events selected for the marquee catalog have not changed with this update, the marquee footprints and intensities have been updated using claims data (for the hail, straight-line wind, and tornado sub-perils) as well as detailed radar data (for the hail sub-peril).

Stochastic Catalog

The Verisk Severe Thunderstorm Model for the United States includes updated stochastic catalogs. These catalogs include more robust regional variation in hail swath length, width, and intensity distributions based on 20 years of detailed radar data processed in Verisk's storm tracking algorithm and validated using storm reports and claims data. As seen in Figure 1 and Figure 2, stochastic catalog event frequency has increased due to the new hazard detrending methodology used to account for population and reporting biases in the annual number of SPC storm reports.

Macroevent Counts	
Stochastic Catalog	Percent Change
10K All-Events	32%
10K Cat-Only	92%
50K All-Events	32%
50K Cat-Only	92%
100K All-Events	32%
100K Cat-Only	92%

Legend	
Percent Change	Color
0% - 20%	
20% - 60%	
60% - 100%	
100% - 140%	

Figure 1. Percent increase in the number of macroevents between the previous and updated 10K, 50K, and 100K all-events and cat-only stochastic catalogs

	Stochastic Catalog	Percent Change		
		Hail	Straight-Line Wind	Tornado
Number of Swaths	10K All-Events	21%	37%	3%
	10K Cat-Only	27%	35%	1%
	50K All-Events	20%	37%	3%
	50K Cat-Only	27%	34%	1%
	100K All-Events	20%	37%	3%
	100K Cat-Only	27%	34%	1%
Average Area of Swaths	10K All-Events	19%	124%	25%
	10K Cat-Only	23%	131%	24%
	50K All-Events	18%	125%	25%
	50K Cat-Only	22%	131%	24%
	100K All-Events	19%	125%	25%
	100K Cat-Only	22%	131%	24%

Legend	
Percent Change	Color
0% - 20%	
20% - 60%	
60% - 100%	
100% - 140%	

Figure 2. Percent increase in the number and frequency of ellipses (swaths) between the previous and updated 10K, 50K, and 100K all-events and cat-only stochastic catalogs, by sub-peril

The Verisk Severe Thunderstorm Model for the United States supports the following two 10,000-year (10K), two 50,000-year (50K), and two 100,000-year (100K) stochastic catalogs in Touchstone, as did the previous version of this model.

- 10K All-events
- 10K Cat-only
- 50K All-events
- 50K Cat-only
- 100K All-events
- 100K Cat-only

2.3 Event Generation

The event generation component of the Verisk Severe Thunderstorm Model for the United States incorporates:

- a significant amount of additional detailed observational data (radar reflectivity, SPC storm reports, CoCoRaHS, and SHAVE) and claims data,
- new research (particularly related to hail),
- a new derecho detection algorithm,
- reduction factor applied to SPC wind data to address reporting bias,
- a new hazard detrending methodology, and
- an improved Verisk storm-tracking algorithm.

The Verisk-developed derecho detection algorithm is based on scientific research and constructs a list of derecho event days using SPC wind reports between 1979 and 2018. This algorithm is highly skilled at detecting both individual historical events as well as the overall U.S. derecho climatology.

With this model update, Verisk researchers detrended the observed annual number of hail and straight-line wind SPC storm reports to remove the false linear time trend present in the earlier years (1979 -2010) due to population and reporting biases, as well as correct for climate change (particularly post-1990) in this dataset. The previous version of the model (released in 2014) assumed 2001 was a baseline year and detrended the data relative to 2001 because, at the time, it was not clear whether event frequency would continue to increase or stabilize. For the 2022 release, the data show that the event frequency has stabilized in recent years, except for 2011, which was a large outlier year. Thus, with this model update, Verisk researchers introduced a new detrending methodology that modifies the severe daily and annual frequencies present in the early years of the SPC storm reports (1979 - 2010) to make them more consistent with recent years. This methodology removes non-meteorological signals while preserving climate-related trends.

Furthermore, Verisk researchers' examination of the SPC convective straight-line wind speed data revealed that the preponderance of SPC reports in the eastern two-thirds of the United States are, in fact, estimated wind speeds, rather than actual measured wind speeds. In addition, Verisk internal research, as well as literature review, indicate that estimated wind speeds are biased 20-30% high when compared to the true/measured wind speed. To address this issue, Verisk scientists applied a reduction factor to the estimated SPC wind reports, by state and wind speed bin; the reduced wind speed reports were then used to build the wind sub-peril catalog.

Verisk researchers improved hail event footprints by incorporating 20 years of detailed NEXRAD Level II radar reflectivity data into the updated model. These data were run through a storm-tracking algorithm that identifies areas of intense storm activity and tracks them through time and space. This algorithm was run daily and identified over three million tracked storms. These storms were subsequently filtered into likely hailstorms using additional data sources, including CoCoRaHS, SHAVE, SPC, and NEXRAD Level III hail signatures. Finally, these event footprints were validated and tuned using storm reports and claims data and are used to inform hail footprint length, width, and intensity probability distributions. These probability distributions are ultimately used to update Verisk's stochastic catalogs.

With this model update, Verisk researchers used spatially-varying generalized additive models (GAMs) to fit a relationship between hail occurrence (obtained from the filtered radar reports) and individual environmental parameters, such as elevation, Convective Available Potential

Energy (CAPE; a metric that approximates updraft strength and atmospheric instability), shear, lapse rate, 500 mb temperature, and specific humidity. While some of these variables are often combined to yield composite parameters, such as Significant Hail Parameter (SHiP), which can indicate conditions favorable for hail formation, these variables were not combined when creating the GAMs to allow for interactions among them. The GAMs probability surfaces were augmented with SPC hail observations (via hybrid statistical-meteorological smoothing).

Impact of the Event Generation Update

New and enhanced event generation components included in the 2022 version of the Verisk Severe Thunderstorm Model for the United States result in a true all-events model that correctly represents the near-present climate. Verisk's new derecho detection algorithm provides an accurate view of derecho climatology in the U.S. The incorporation of a new hazard detrending methodology removes population and reporting biases present in the data and results in more events in the stochastic catalog than the previous (2014) version of the model for all three sub-perils. The improved Verisk storm-tracking algorithm also reduces population biases and provides a better hailstorm footprint extent and intensity distribution than just using storm reports alone.

The new hazard detrending methodology ensures that, when the stochastic catalog is built, the count and location of microevents on each simulated day are reflective of near-present climate conditions, no matter which seed day is selected. In addition, when the model is built, the attributes of each simulated hail microevent are drawn from probability distributions, which are created from a blend of SPC storm reports and radar-based hail swaths. Due to the growth in SPC storm reports over time (1979 - 2010), these probability distributions are implicitly weighted toward the more recent years (post-2010) to result in more hail events. The radar data used to create the hail distributions range between 1996 and 2018. Thus, the hail probability distributions are further implicitly-weighted toward more recent years, ensuring that each simulated hail swath's attributes are reflective of near-present climate conditions.

The updated model's daily probability surfaces for hail represent a blend between environmental conditions and observations, like the existing model, while allowing for realistic interactions among variables that contribute to hail formation. Figure 3 is an example of underlying radar reflectivity data with Verisk-modeled ellipse footprints (dark blue ellipses) output by the storm-tracking algorithm for the May 10, 2010 historical event. Overlaid on this image are hail reports (green triangles) and claims data (blue circles). Using the radar data creates better storm footprints than just using storm reports alone, as evidenced by the sparsity of reports in some of the ellipses. Note that some of the claims data are outside the event footprints, which is most likely due to incorrectly assigned date of loss to claims. Severe thunderstorms (not shown) that occurred a few days after this event align with some of the clusters of missed claims seen in this image.

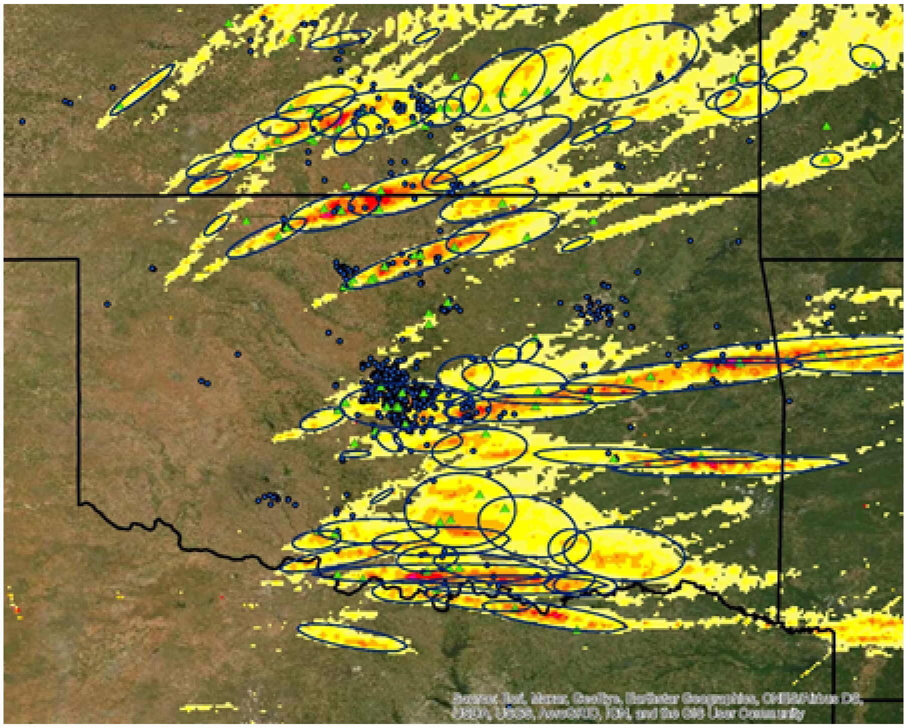

Figure 3. Example of radar reflectivity overlaid with Verisk-modeled ellipse footprints (blue ellipses), SPC hail reports (green triangles), and claims data (blue circles) for the May 10, 2010 historical event

Detailed hailstorm footprints provide accurate length, width, and intensity probability distributions, which are, in turn, sampled to inform Verisk's stochastic modeling and ultimately produce the model's stochastic catalogs. The inclusion of a large radar reflectivity dataset allows Verisk researchers to build robust regional variation into these probability distributions and, hence, Verisk's stochastic catalogs. For example, greater swath lengths occur, on average, in the central U.S. as compared to other regions (Figure 4).

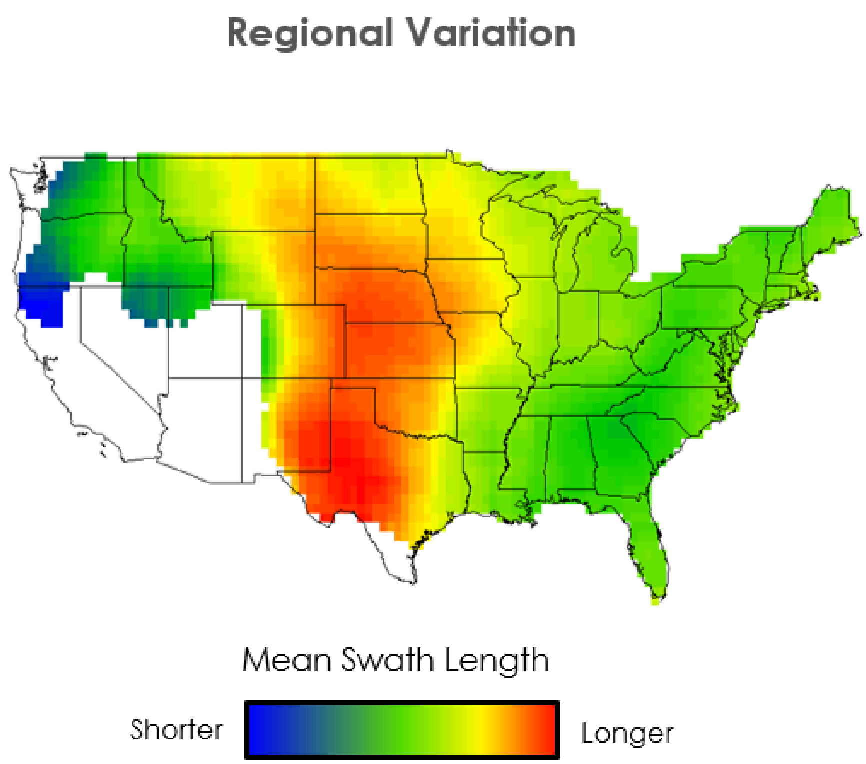

Figure 4. Example of regional variation in July hail swath length

2.4 Local Intensity Calculation

The local intensity calculation component of the Verisk Severe Thunderstorm Model for the United States incorporates a significant amount of additional observed and claims data, new research (particularly related to hailstorms), and a spatially-varying hail intensity profile within an event footprint. The previous (2014) version of the model keeps hail intensity uniform throughout an event footprint but, in reality, there is quite a bit of variability in intensity throughout a given hail swath. To account for this variability, Verisk researchers built an "intra-swath hail intensity variation" profile into the hail footprints in the updated (2022) model. As a result, areas close to the center of a simulated hail footprint have greater intensity than along the edges. The methodology for calculating straight-line wind and tornado intensity remains unchanged with this update.

Impact of the Local Intensity Calculation Update

The inclusion of a spatially-varying approach to hail intensity in the local intensity calculation component of the updated Verisk Severe Thunderstorm Model for the United States produces more granularity in hail intensity and less damage smoothing within an event footprint. As a result, users are provided with more realistic hail swath profiles, with greater damaged areas near the center and less damaged areas near the edges of an event footprint, as seen in Figure 5. Note that the pattern of hail sizes within a footprint can vary significantly between storms.

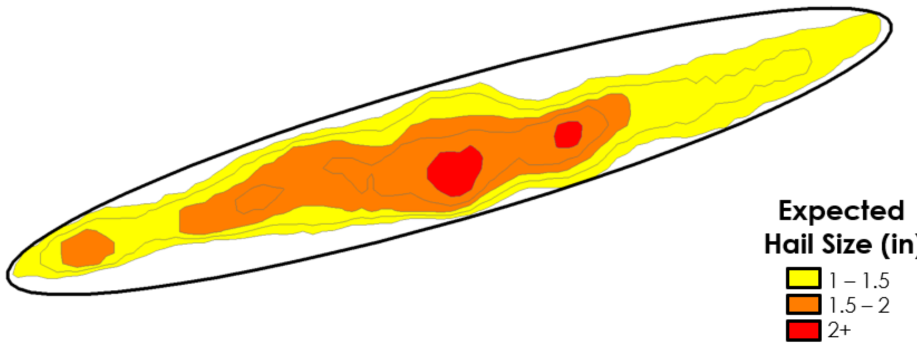

Figure 5. Example of a radar-predicted spatially-varying hail intensity footprint from May 10, 2010 using Verisk Respond data

2.5 Damage Estimation

The damage estimation component of the updated (2022) Verisk Severe Thunderstorm Model for the United States incorporates an innovative component-based hail vulnerability framework, significant amount of additional data (company claims, industry losses, building code enforcement, replacement cost, and roof age data), insights from in-house and published engineering studies, updated damage functions, expanded specialty lines of business risk support, and increased secondary risk characteristic (SRC) support. In addition, a fourth building year-built band is added to the updated model to capture the impacts of the 2012 and later versions of the International Code Council building codes. These codes reference the 2010 vintage of the American Society for Civil Engineers 7 (ASCE 7-10) load standard regarding design wind speed maps.

For the 2022 model release, Verisk engineers completely rebuilt the model's hail vulnerability framework based on engineering studies, literature, innovation, additional Verisk datasets, and market feedback. Within this framework, a structure is decomposed into a series of systems, including the roof (e.g., roof covering, roof deck, etc.), wall, interior, and non-damageable (i.e., additional building components that are not expected to experience hail damage) systems. Verisk engineers focused on evaluating roof-related damage, roof age, re-roofing details, building height granularity, and square-footage differentiation, among other aspects.

Additionally, the effect of aging has been updated for the 2022 model release. For example, a structure constructed in the year 2010 has aged since the 2014 version of the model was released and is therefore more vulnerable in the updated (2022) model than in the previous (2014) model version. The updated model also includes roof age band and roof age assumption updates within the wind damage framework. For all buildings built from 2010 to the current year, the Verisk model assumes a new roof, which leads to decreased vulnerability when compared to the prior version of the model. If a building was built between 2000 and 2009, it is reasonable to assume that, in the absence of user data, the roof has not been replaced. Therefore, an average roof is assigned to the structure, which leads to a slight decrease in vulnerability compared to the previous version of the model. Structures built before 2000 are assigned an unknown roof age in the absence of additional roof year-built information, which aligns with previous model assumptions. The exception to this assignment is for single- and multi-family homes as well as apartments and condos that are constructed from wood or masonry. In these cases, structures that are built prior to 2010 are assigned a roof age based on county roof age averages from the Verisk Roof Age dataset.

Individual damageability curves were developed for each component. Specifically for the hail sub-peril, these curves describe the percentage of the component that exceeds limit states/ damage mechanisms at various levels of hail impact kinetic energy. Limit states or damage mechanisms are component-specific and describe how the individual components perform when subject to hail impacts. For instance, these responses could be denting, cracking, or fracturing for roof covers. The relationship between various building features and the corresponding hail impact kinetic energy imparted on a structure are also considered (e.g., a building's roof slope impacts the number of hailstones affecting the roof and the energy they impart on the roof's components). Cost data, obtained from Verisk's 360Value and RSMeans, are used to understand the proportion of the total building replacement value that should be assigned to each component. Weights are developed using this information and are, in turn, used to aggregate the individual damageability curves to obtain a building-specific damage function. As a user inputs primary and secondary building characteristics, the building's cost breakdown changes. If a user specifies primary features (including the structure's location and year-built) but does not specify any secondary features, this information can be supplemented using assumptions determined from an extensive in-house building code adoption and enforcement study using data valid as of the year 2020. While the aforementioned building code study was already available and implemented for the straight-line wind and tornado sub-perils in the 2014 version of the model, the study is implemented for the hail sub-peril for the first time with this 2022 model update. In addition, all three sub-perils are now updated with building code data available through 2020.

The model incorporates updates to the hail, straight-line wind, and tornado damage functions for residential and commercial structures, manufactured homes, automobiles (hail update only), industrial facilities, and infrastructure risks. The wind and tornado vulnerability of reinforced masonry buildings greater than three stories tall, small industrial facilities, and concrete and steel single-family homes were modified to more closely align with engineering-based expectations based on learnings since the last model update. Additionally, all unknown wind and tornado damage functions were updated based on weights determined using the 2019 version of the Industry Exposure Database. These include functions for traditional building risks with occupancy codes 300 and 301, construction codes 100 and 111, and unknown height damage functions.

Manufactured home vulnerability has changed significantly with this update. A new U.S.-wide manufactured home damage framework was included in the updated model that accounts for spatially and temporally varying straight-line wind and tornado vulnerability differences in manufactured homes due to variability in HUD codes over time and space. Also included are new learnings from wind-related claims, largely from hurricane events, that were used to inform Verisk's manufactured home wind vulnerability relationships.

In addition, the 2022 version of the model expands support for several specialty lines of business, including infrastructure risks (bridges, pavements, dams, tunnels, storage tanks, pipelines, chimneys, towers, railway, canals, and earth-retaining structures), equipment, cranes, conveyor systems, wind turbines, greenhouses, and marine risks (inland transit/ transit warehouse, marine hull, marine cargo, and marine craft, among others). Building, appurtenant structures, contents, and time element damage relationships were re-evaluated in this model update and led to modifications to content and time element damage functions.

The updated model supports 27 convective straight-line wind and tornado SRCs and 13 hail SRCs. Newly-supported SRCs include certified structures (IBHS) for all three modeled sub-perils, and roof deck, roof geometry, and wall attached structure for the hail sub-peril. Appropriate features associated with the various home and commercial IBHS FORTIFIED certification levels (Roof, Silver, Gold, and FORTIFIED for Safer Living/Business) were identified such that, when a user specifies a certification level, the associated features are automatically assigned to the building. In addition, the roof year built secondary feature has been enhanced to explicitly account for roof upgrades. Since a roof must meet the building code requirements at the time of a roof's upgrade, these requirements are assigned to the roof-related features when a user enters roof year built. When a single- or multi-family home roof year built is unknown, county-level average roof age information is assigned to this home based on proprietary Verisk roof-age data. These detailed data are current as of 2019.

2.6 General Impact of Model Updates on Loss Estimates

The general impact of the Verisk Severe Thunderstorm Model for the United States updates on gross insurable occurrence and aggregate losses is presented in the tables available through the link below. These loss changes are due to hail, straight-line wind, and tornado losses combined as well as by individual sub-peril, and include demand surge. They represent the percentage change in loss estimates calculated by the previous version of Touchstone [2021 (9.0)] as compared with those calculated by the current version of Touchstone [2022 (10.0)], for the model domain (conterminous United States), each region, each state, and the District of Columbia, using the 10,000-year all-events and 10,000-year cat-only stochastic catalogs.

Loss changes are calculated using Verisk's 2019 Industry Exposure Database (i.e., "constant exposure"). Verisk typically runs the model with the full Industry Exposure Database. Given the 90-m resolution of the database, coupled with the high model resolution and number of events, Verisk ran a subset of the Industry Exposure Database consisting of a random sample of 10% of the Industry Exposure Database, without any state or line of business bias to generate the loss changes presented in the tables available through the link below. Please note that Verisk used the full Industry Exposure Database to generate the industry loss files for this model.

The following loss change tables are available for hail, straight-line wind, tornado, and all three sub-perils combined:

- Gross Insurable Occurrence Loss Changes:
  - 10K All-Events Catalog
  - 10K Cat-Only Catalog
- Gross Insurable Aggregate Loss Changes:
  - 10K All-Events Catalog
  - 10K Cat-Only Catalog
- Analysis Settings

Caution should be exercised before relating the industry changes shown here to a particular portfolio. The changes to individual books of business may deviate from the losses represented here to the extent that their exposure spatial distribution and construction/ occupancy mix deviate from industry averages.

While occurrence losses have remained relatively stable across the conterminous U.S. as a whole, occurrence and aggregate losses for all perils combined have generally increased across most regions and lines of business, with larger changes seen in aggregate losses, with this model update. Some of the more significant percentage increases are seen in the West and in Florida; and some of the smallest percentage increases and/or slight decreases in losses are evident across the Northern and Southern Great Plains and the Midwest. The manufactured home and automobile lines of business experienced the greatest percentage increases in loss, while the residential and commercial lines of business had the smallest increases and/or slight decreases overall. These changes can be explained by both the significant hazard and vulnerability updates made to the model. Details regarding these changes are described by sub-peril below.

Impact of Hail Updates on Loss Estimates

Hazard updates to Verisk's hail modeling approach results in an approximately 30% increase in the frequency of severe hail days in the model. However, these changes are not spatially uniform. Specifically, the model shows a broad increase in hail frequency across much of the contiguous United States, with notably higher hail frequencies in the Northern Plains (particularly Kansas, Nebraska, and Oklahoma), the Northeast, and the Southeast (particularly Georgia, South Carolina, and North Carolina) compared to the previous model version. These higher hail frequencies contribute to increases in aggregate losses in these regions. These changes validate well against near-present observed severe thunderstorm day frequency and are consistent with our expectations based on changing meteorological conditions.

Significant vulnerability updates include the introduction of an innovative component-based hail vulnerability framework and recalibration of all vulnerability relationships such that modeled losses closely align with claims data. The hail vulnerability update cannot be considered an incremental vulnerability update with respect to the previous version of the model because the hazard definition changed between the prior and updated versions of the model. Specifically, in the prior model version, each hail microevent was assigned a total hail impact energy, which is designed to capture the distribution of hail sizes in the ellipse, as well as hailfall duration and horizontal wind speed. In the updated model version, an intensity profile is additionally applied to each hail microevent, yielding a spatially-varying total hail impact energy within the swath—with higher intensity toward the swath midline and decreasing intensity toward the edges of the swath. Therefore, it is not possible to separate the impact of the vulnerability updates from the hazard updates. As a result, these changes must be collectively compared to the prior version of the model.

Relationships between lines of business were also reassessed. Manufactured home vulnerability compared to traditional building risks was re-evaluated based on material and cost information within the hail vulnerability framework. Quantifying the relative impact of this update is not straightforward, as various locations will result in different magnitudes of change due to spatial and temporal vulnerability variations for traditional building risks. However, on an industry-wide basis, these changes led to an increase in manufactured home hail vulnerability when compared to traditional building risks for low hail intensities. In addition, automobile damage functions were re-evaluated for both personal automobiles and dealerships, which resulted in an expected increase in automobile line of business losses relative to loss changes for traditional building risks for low hail intensities.

Impact of Straight-line Wind Updates on Loss Estimates

As a result of the new hazard detrending methodology, the updated model shows a broad increase in convective straight-line wind frequency across the United States, most notably in the Great Plains, the Mid-Atlantic states, the Southeast, and the Northeast. However, this increase in frequency does not necessarily result in increased losses in these regions of the model domain, due to the application of a reduction factor to the estimated SPC wind speed reports. As a result, the average wind speed in the updated model has decreased relative to the previous model version, but the amount of wind speed reduction is region-specific. Therefore, the region-specific interaction between the increase in wind frequency and the decrease in wind intensity drives the hazard contribution to the loss changes seen in each region of the model domain. In general, regions that exhibit notably higher wind frequencies and lower average wind speed show an increase in aggregate loss, but not necessarily a decrease in occurrence loss. In regions with little change in frequency, the reduction in mean wind speed results in lower occurrence and aggregate losses.

Vulnerability updates to the wind damage framework (including updates to building codes and default damage framework features, the aging and deterioration of structures, recalibration of damage functions, and updates to unknowns due to the incorporation of new datasets) provide relatively minor changes at the industry level for most risks. In addition, the recalibration of contents and time element damage functions results in some decreases in contents and time element losses for lower intensity events.

This vulnerability update has implications for traditional buildings constructed since the last model update. In general, building vulnerability decreases for newer buildings because newer building codes are typically more stringent and better enforced than older codes. There are exceptions to this generality, most notably in some coastal areas where the 2012 International Building Code and International Residential Code specified lower design wind loads based on the 2010 ASCE 7 standards. The inclusion of recent building codes results in a varying degree of model changes based on the actual location of the risk.

The vulnerability updates described above are relevant to traditional building risks and affect the wind vulnerability of the residential and commercial lines of business. These updates have moderate impacts on the vulnerability of individual risks. Most of the vulnerability updates described above affect the vulnerability of primarily newer structures, which, on average, result in decreased vulnerability due to the incorporation of recent building code assumptions and more specific roof aging criteria. This decreased vulnerability is balanced by the aging of the overall building stock. Thus, these updates cause relatively small loss changes to the industry view of wind risk for residential and commercial lines of business. Commercial risks experience more significant decreases in vulnerability than residential risks due to the impact of damage function modifications to content and time element losses for lower wind speed events.

Manufactured home vulnerability updates have led to a significant increase in the vulnerability of manufactured homes that is visible in the industry-based manufactured home EP curves. Automobile wind vulnerability did not change significantly with this update. Therefore, it is expected that most of the gross insurable loss changes for this line of business are a result of region-specific wind hazard modifications. Specifically, many regions show an increase in automobile losses across several return periods, which is driven by the higher modeled wind swath frequencies in these regions with this update.

Impact of Tornado Updates on Loss Estimates

Hazard modifications for the tornado sub-peril include an increase in frequency in the Southeast and Florida (predominantly during the cool season). This frequency increase is due to the increase in tornado occurrence in these regions, as present in the new observational data with this model update. Increased losses for tornado are therefore expected in these regions across all lines of business. The Mid-Atlantic region also shows a modest increase in tornado frequency with this update. Thus, relatively small loss increases for tornado are also expected in this region.

Vulnerability modifications to the tornado framework are similar to those described for wind above. Losses associated with tornado damage for the residential and commercial lines of business result in minimal impacts due to damage function and tornado damage framework updates at the industry level. Content and time element damage function vulnerability relationship updates do not have as much of an impact on tornado loss changes as was previously noted for wind. The content and time element relationships were recalibrated primarily for lower intensity events. Tornado events are typically accompanied by high wind speeds. Therefore, as expected, these modifications result in less of an impact.

Manufactured home tornado vulnerability has increased due to the inclusion of new wind data and a manufactured home tornado damage framework that accounts for spatial and temporal vulnerability with this model update. Automobile tornado vulnerability was largely unchanged with this model update. Thus, the impact to the automobile loss changes associated with tornado damage are expected to be largely hazard driven.

3 Event ID Updates

The following table lists changes to event IDs in the updated models forTouchstone in 2022.

Table 1. Stochastic Event ID Updates

Verisk Model	Stochastic Event IDs
Verisk Severe Thunderstorm Model for the United States	All event IDs are new.

About Verisk

Verisk Analytics (Verisk) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, a Verisk subsidiary founded the catastrophe modeling industry and today models the risk from natural catastrophes, terrorism, pandemics, casualty catastrophes, and cyber incidents. Insurance, reinsurance, financial, corporate, and government clients rely on Verisk's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, longevity modeling, site-specific engineering analyses, and agricultural risk management. Verisk (Nasdaq:VRSK) is headquartered in Jersey City, New Jersey with many offices throughout the United States and around the world. For information on our office locations, visit https://www.verisk.com/about/locations/.

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