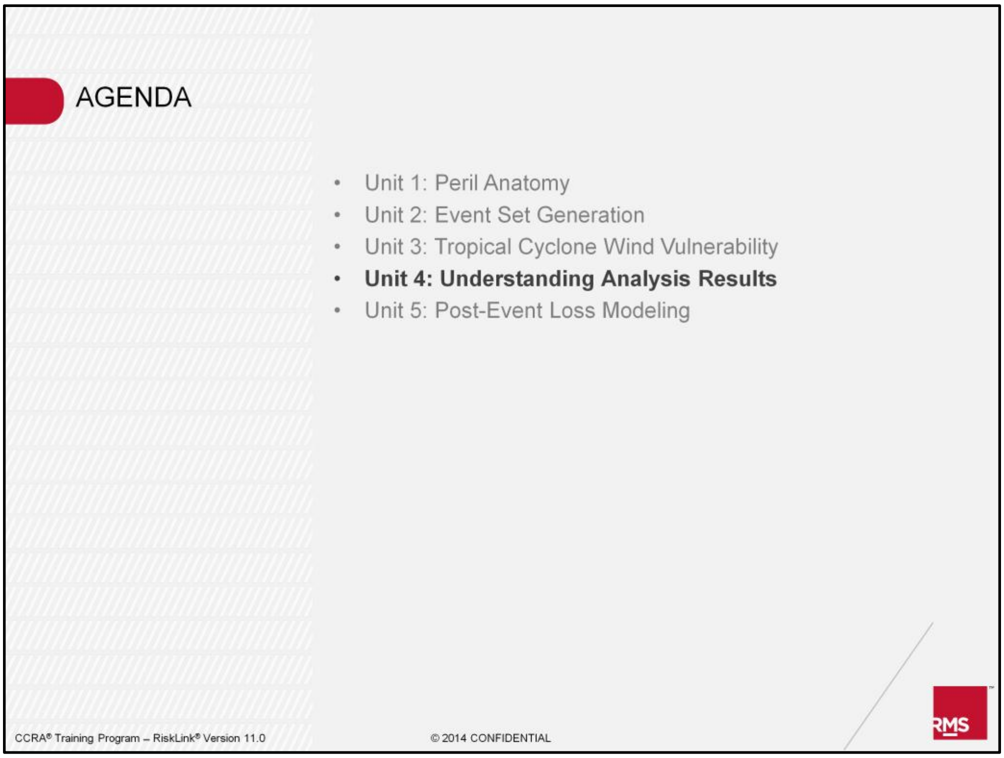
TROPICAL CYCLONE MODELING

UNIT 4

RMS® CCRA® Training Program

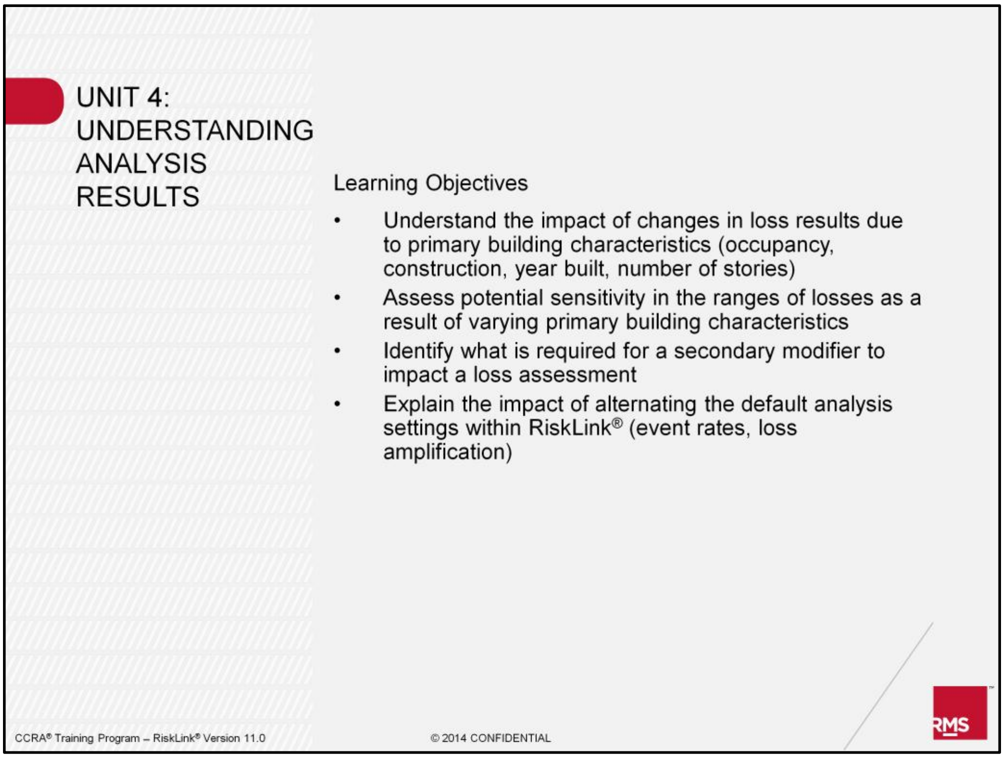
Certified Catastrophe Risk Analyst



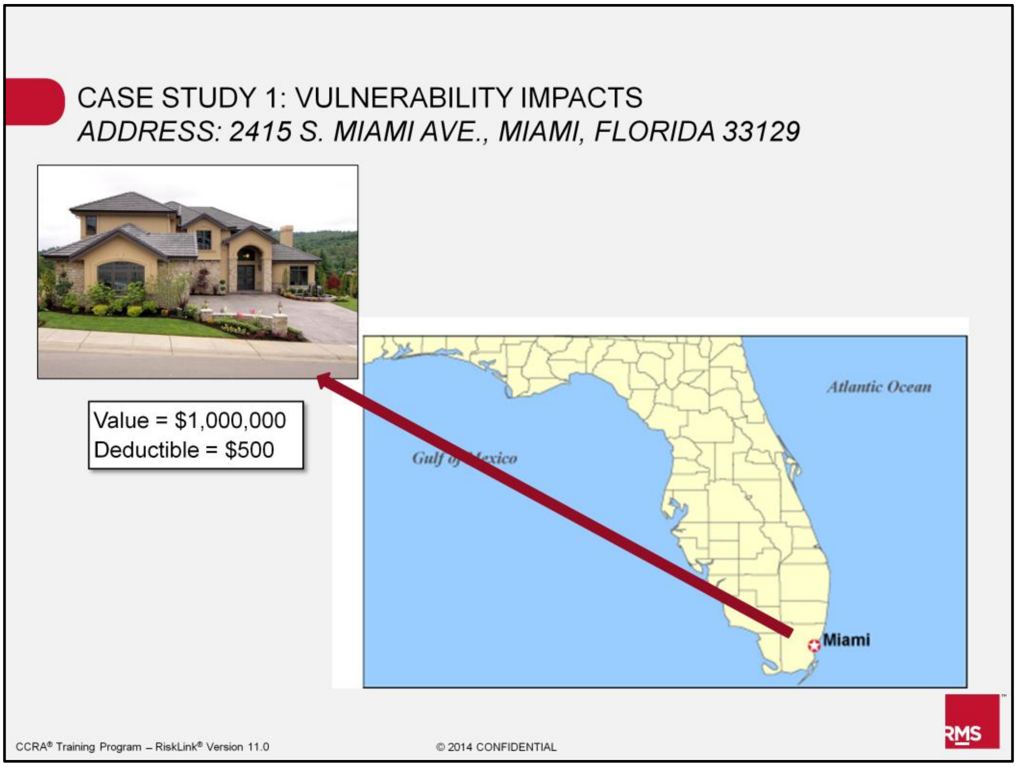
This is the agenda for the Tropical Cyclone Modeling course.The fourth of five presentation units in the course covers case studies that provide insight into tropical cyclone model results.

This unit includes the following sections:

- Case Study 1: Vulnerability Impacts
- Case Study 2: Regional Impacts
- Case Study 3: Loss Amplification
- Case Study 4: Stochastic Event Rate

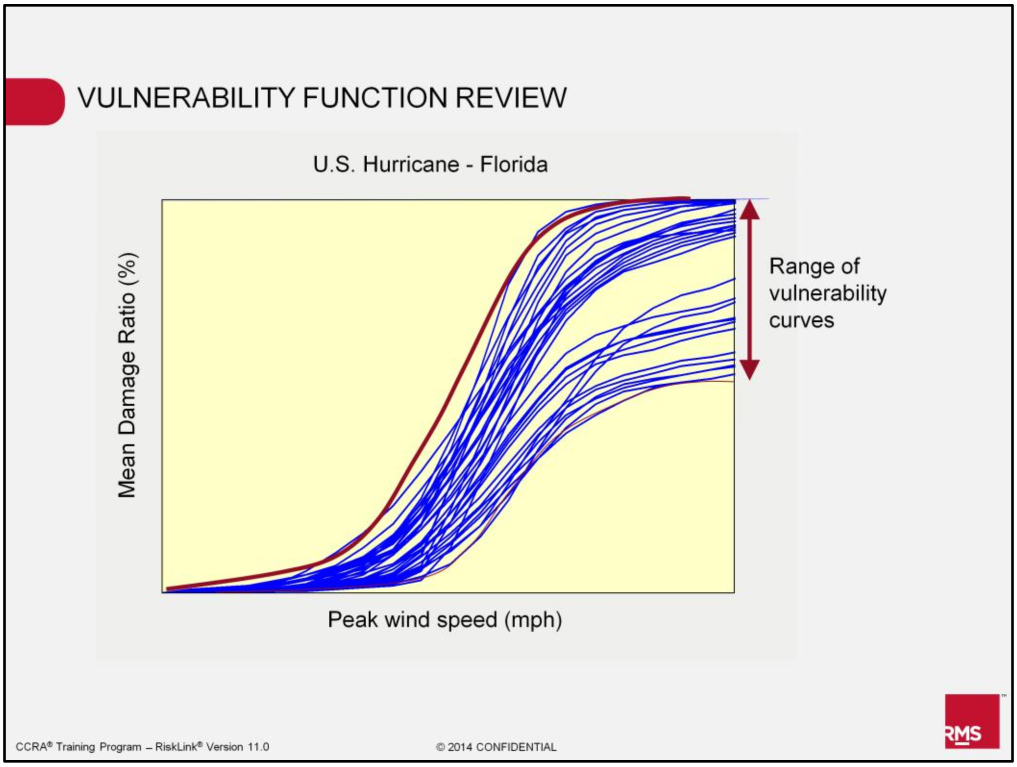


At the end of this unit you should have a good understanding of each of the six learning objectives listed on this slide.



Four case studies are explored in this unit. They all are based on the results of analyses performed on a structure in a southern Florida location at 2415 S. Miami Ave., Miami, FL 33129. Primary characteristics are altered to provide an understanding of the impact of these changes on U.S. hurricane analysis results. In addition, the impact of loss amplification and the use of different events rates at this site are discussed. Finally, regional differences in loss on the same type of risk are explored.

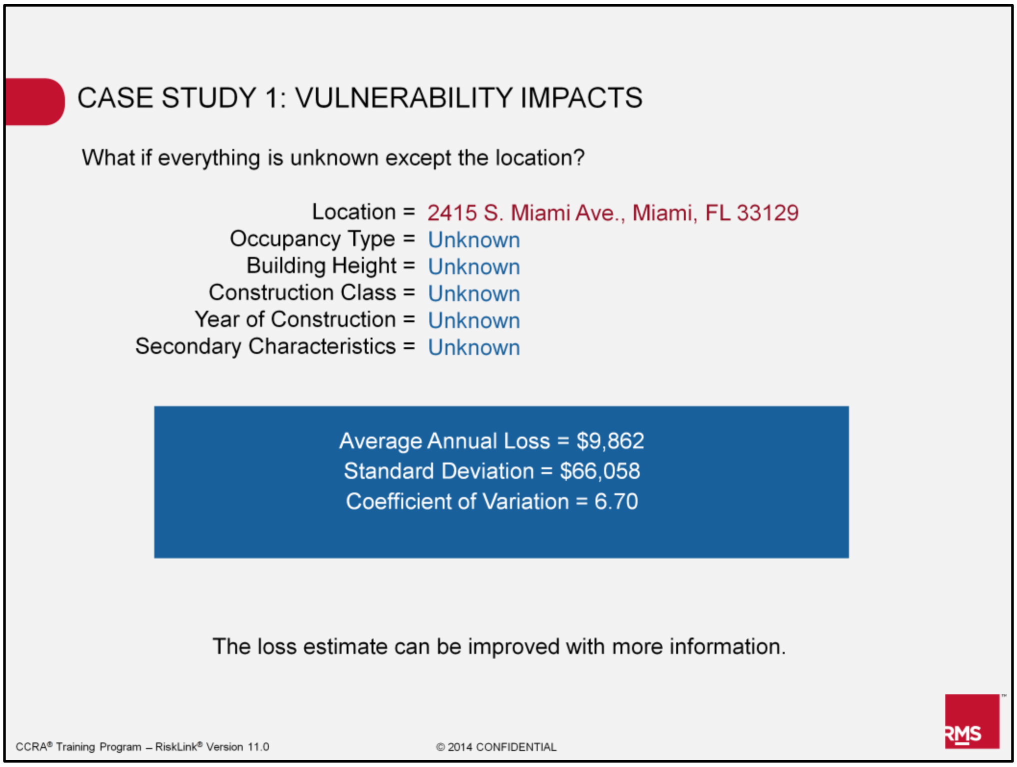
The first case study illustrates how different primary building characteristics impact the vulnerability assessment and resulting losses at a given location. Coding in as much detailed information as possible will provide the most accurate assessment. For this example, we use a location at 2415 S. Miami Ave, Miami, FL with an insured value of $1 million and a deductible of $500.



Prior to starting the first case study, it is worthwhile to quickly review windstorm vulnerability functions. Four elements that are critical in defining a vulnerability function are occupancy type, construction class, building height, and year of construction. The main types of occupancy type are industrial, residential, and commercial. Particularly for commercial occupancies, there is a wide range in potential losses as a result of a specific occupancy (office, hotel, retail, church, school, etc.). The main generic types of construction class are wood frame, masonry frame, reinforced concrete or steel frame, and light metal frame.

As an example, shown in the figure above is a schematic of the range of possible vulnerability curves for a commercial building of some specified construction. Differences in the curves are due to variations in year built and building height combinations (Note: This is a schematic and actual vulnerability curves are not shown). The range of vulnerability curves, and thus mean damage ratios (MDR) at various wind speeds, can translate to a wide range of average annual loss (remember that AAL = MDR * value). Thus, the upper curve can result in losses over an order of magnitude higher than the lower curve.

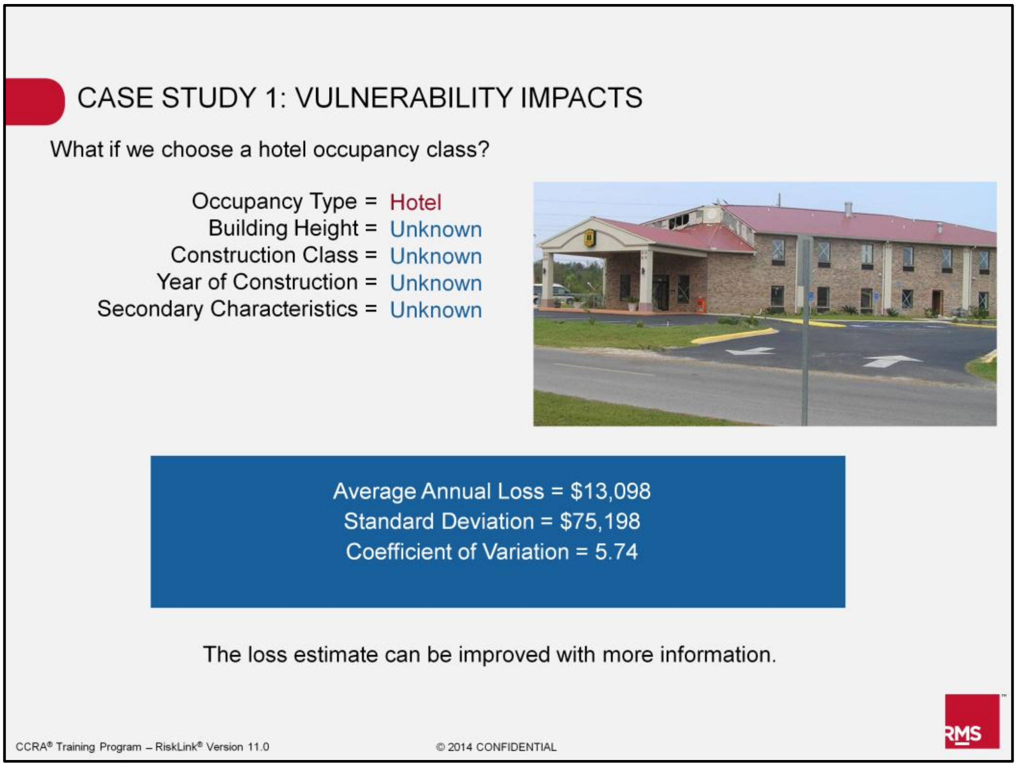
For windstorm exposed buildings (for a given combination of occupancy, construction class, and age), taller buildings tend to be less vulnerable than shorter buildings. This is from a damage ratio perspective, not from a pure dollar loss perspective. This difference in vulnerability is partially due to the stricter standards of design, construction, and maintenance applied to taller buildings, and is largely due to the relative importance of the roof and cladding elements for buildings of different heights. In general, a building's vulnerability increases with age, due to varying building codes as well as deterioration of materials over time.



This first case study will walk through coding in important features in defining the vulnerability of this building at 2415 S. Miami Ave. in Miami, FL 33129. In each slide we will code in different elements of the vulnerability function and observe how the AAL, standard deviation, and coefficient of variation are affected.

The starting point is to set all of the elements or building characteristics that define a vulnerability curve to unknown. In cases where a building's occupancy, construction class, construction year, and/or height are not specified, the U.S. hurricane model uses RiskLink's building inventory database to develop a composite vulnerability function for the location of interest. The building inventory database contains an industry mix of the building stock found in various regions of the U.S. The inventory mix proportions are used as weighting factors to create a composite vulnerability function from a selected set of curves associated with those building characteristics that the user has specified. The resulting composite vulnerability curve represents the average vulnerability of those building types associated with the specified characteristics. As will be discussed in more detail later in this unit, if the building inventory assumptions are invoked, secondary modifiers will not impact loss assessment, even though a secondary modifier may still be coded for a location. ***Note:*** *It is important to enter at least occupancy if known in order to select inventory vulnerability functions that incorporate a more refined set of construction mixes.*

The analysis results based on the composite industry mix vulnerability function, are listed on the slide.



The next scenario is to select an occupancy class, in this case hotel, and leave everything else as unknown. You will notice that the AAL has increased to over $13,000. Hotels (or other temporary lodging) tend to be more vulnerable than the industry average mix invoked by setting the characteristic to unknown. Since we have identified an occupancy our coefficient of variation has decreased to 5.74, correctly reflecting less uncertainty around the loss. While this location only has the building coverage coded for values, it is important to note that the business interruption costs of hotels are generally higher than other commercial occupancies.

Generally, coding occupancy as unknown should be avoided, as the model calculates losses based on a composite vulnerability curve of general residential, commercial, and industrial. At a minimum, the general classification should be known, and the specific occupancy is increasingly critical to a proper loss assessment. In a study of the 2004 claims data in which RMS collected over $10 billion in claims, over 95% of the exposure data included an occupancy other than unknown.

CASE STUDY 1: VULNERABILITY IMPACTS

What if we choose an office building instead of a hotel?

Occupancy Type = Office Building
Building Height = Unknown
Construction Class = Unknown
Year of Construction = Unknown
Secondary Characteristics = Unknown

Average Annual Loss = $9,397
Standard Deviation = $64,095
Coefficient of Variation = 6.82

The loss estimate can be improved with more information.

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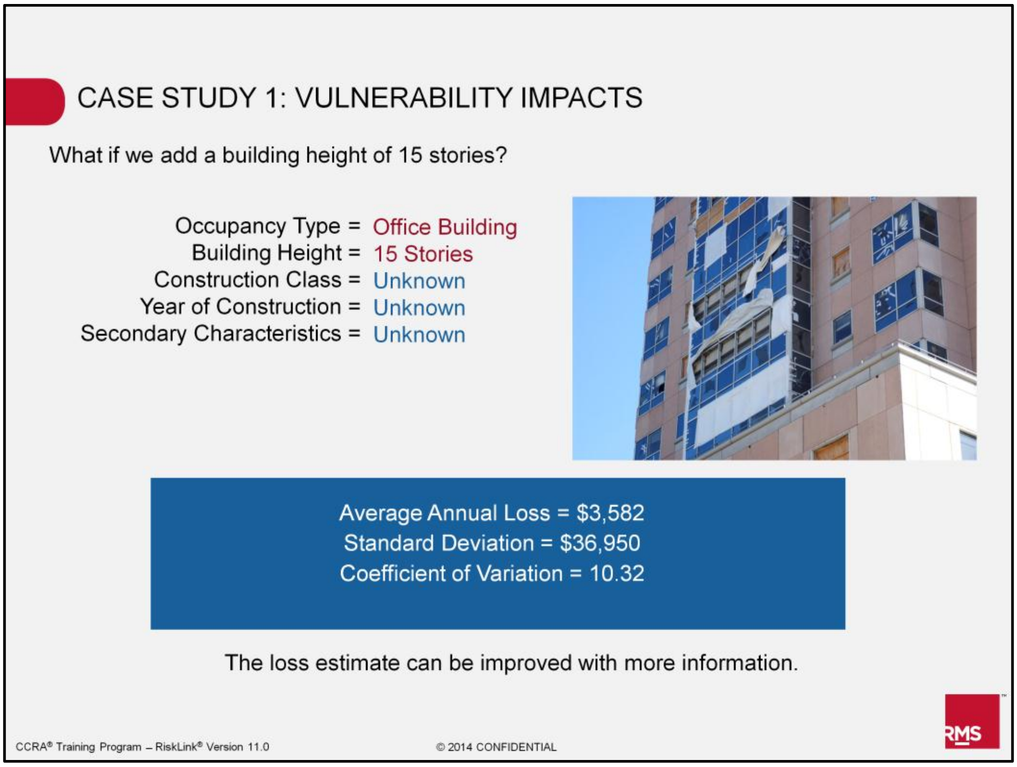
If an office building instead of a hotel occupancy is chosen, the AAL drops almost $4,000, reflecting the greater vulnerability of hotels.

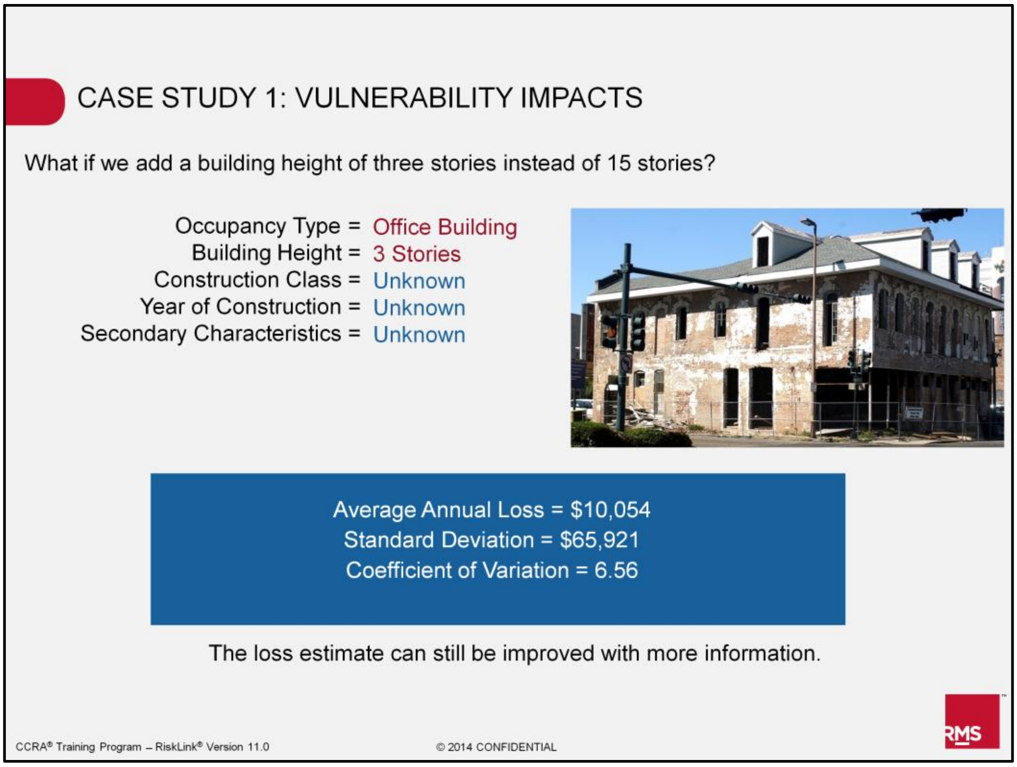
You will have noticed while the AAL has dropped, the CV has increased between office building and hotel. In this instance, the AAL has decreased more than the standard deviation, thus the CV is larger. As a general rule, the uncertainty around tropical cyclone losses *increases* as the loss *decreases* because the range of observed damage over a region is larger at lower wind speeds than at higher wind speeds. ***Note:*** *Refer to Unit 3 of the Uncertainty Measures course for detailed treatment on the subject of the development of the MDR/CV relationships by peril and region.*

Several sources for the range of potential losses around the modeled mean for this building include: complex building shape/configuration, a range of cladding types on the building, and the range of potential construction. Given that all of the other construction characteristics are coded as unknown, the CV is necessarily large in order to reflect the broad range of possible combinations of vulnerability elements used to define the vulnerability functions.



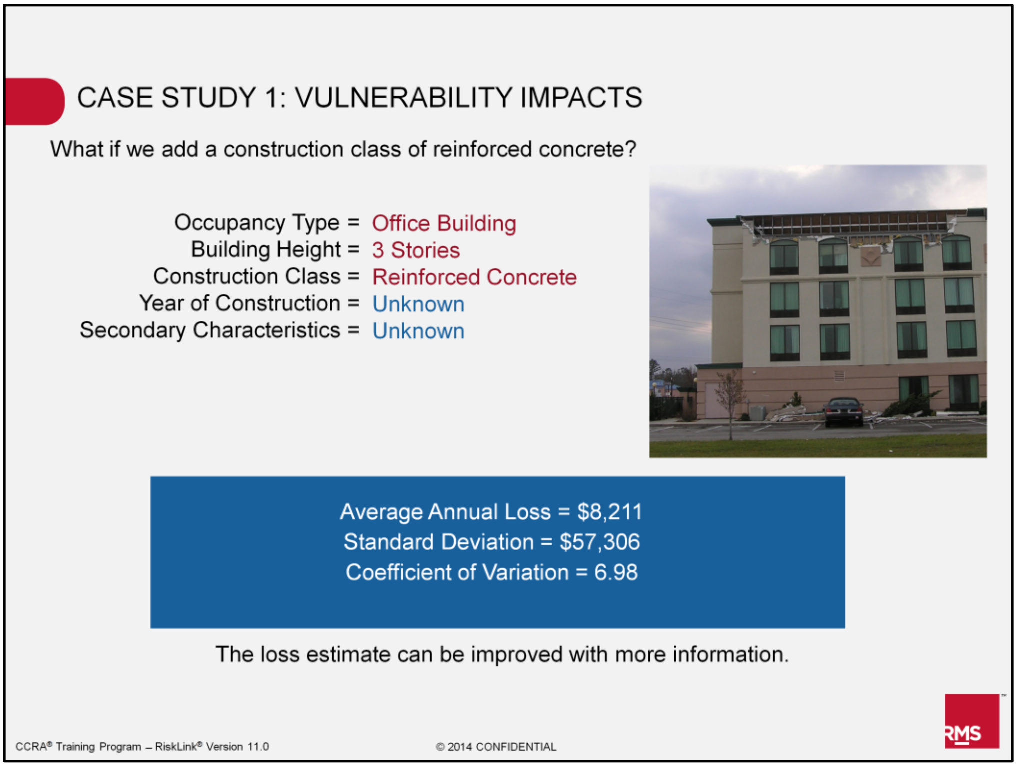
We will continue with using office building as the selected occupancy, and now select a building height. If we choose an office building with a height of 15 stories our AAL drops considerably to a little over $3,500, a decrease of nearly $6,000. The decrease in AAL is likely due to the fact that high rise office buildings are constructed with either steel or reinforced concrete. In particular, high rises above eight stories almost always have a concrete roof, rather than a panel roof. These two factors are likely the primary drivers of the significant decrease in AAL.

The increase in the CV may be a bit counter-intuitive, but again, it is important to note that there are two drivers: AAL and standard deviation. The higher CV is a reflection of the two-thirds decrease in AAL, while the standard deviation only decreased by 50%. Thus, the AAL change is a larger driver of the CV increase, rather than the standard deviation. Entering unknown for the other characteristics is continuing to provide significant uncertainty around the modeled mean loss.



Assume we lower the height building to three stories instead of 15. This more highly vulnerable classification results in an increase of AAL by $6,500, and is likely driven by the larger inventory distribution that is assumed for a low rise building: a mix of masonry, light metal, steel, reinforced concrete, and wood. As a result of adding some of the more vulnerable construction classes to the inventory mix (light metal, masonry, wood), the AAL is expected to increase.

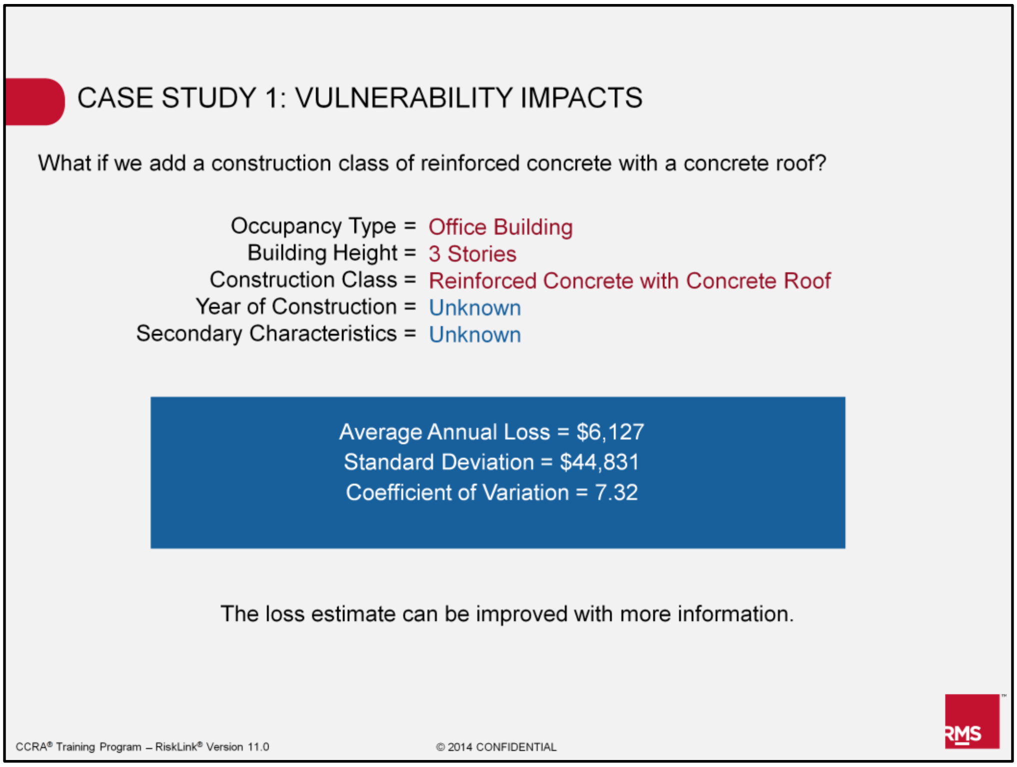
If we compare the coefficient of variation when we only had an occupancy type of office building and everything else was unknown, the CV was 6.82. By adding the building height we have decreased the uncertainty to 6.56. Adding another source of information from which to assign a vulnerability function helps to reduce the uncertainty around the loss.



The next element to be defined is construction class. For this example we will choose an office building with three stories and reinforced concrete construction. Reinforced concrete is on average less vulnerable than most other construction classes in the inventory assumption, and thus our AAL has decreased from $10,054 to $8,211.

The standard deviation has decreased but not as much as our AAL. Thus, the CV is a little higher than the previous example. Again, the significant lowering of the AAL is driving the slight increase in CV.

Inventory assumptions vary by occupancy type for the roof type on a reinforced concrete building, but a general rule of thumb is that one to three story reinforced concrete buildings are predominantly panel roofs for this region. For buildings four to seven stories, the inventory assumption for reinforced concrete building is predominantly concrete roofs. For reinforced concrete buildings higher than seven stories, the inventory assumption is to assume all concrete roofs.



Based on our assumption posed in the last slide, instead of a reinforced concrete construction class we will choose a reinforced concrete (RC) construction class with concrete roof. As expected, by coding in a concrete roof our AAL has decreased to about $6,000. Concrete roofs are less vulnerable than panel roofs, thus the mean loss has decreased. In the previous slide, the construction is modeled as a weighted combination of panel and concrete roofs.

However, it is interesting to note that the CV has increased slightly. This is caused by the MDR-CV relationships that are built into the model that say for low building damage ratios, the uncertainty in loss estimates (measured by CV) is higher. Thus by reducing the mean loss, we reduce the loss ratio and will increase the CV ratio as a result. Note, however, the absolute magnitude of the standard deviation between these two cases has dropped indicating lower overall uncertainty in the final loss numbers.

As a rule of thumb, if roof type is unknown, it is better to have RiskLink utilize the inventory assumptions rather than making a guess that may or may not be correct.

CASE STUDY 1: VULNERABILITY IMPACTS

What if we add the year of construction to be 2002?

Occupancy Type = Office Building
Building Height = 3 Stories
Construction Class = Reinforced Concrete with Concrete Roof
Year of Construction = 2002
Secondary Characteristics = Unknown

Average Annual Loss = $1,973
Standard Deviation = $23,766
Coefficient of Variation = 12.04

The loss estimate can be improved with more information.

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The next element we will address in the refinement of the vulnerability curve for this building is the year of construction. For this example we select a relatively new office building with the year of construction set at 2002. Notice the large decline in AAL reflecting that newer buildings tend to be less vulnerable than older buildings, due to more stringent building codes and code enforcement. The 2002 to present year of construction band impact on the vulnerability function is applicable only to the state of Florida, given the revised building codes implemented in 2001. In FL, the inventory assumption on year of construction is 72% pre-1995, 19% 1995-2001, and 9% 2002-present, and thus the unknown year of construction curve assumes this weighted distribution for the aggregate unknown vulnerability function.

A larger CV for the post-2002 data is likely due to the fact that the mean loss has decreased significantly. The mean loss has decreased as a result of the post-2002 vulnerability function having lower damage ratios at higher wind speeds than the unknown vulnerability curve. For any vulnerability function, there is generally a wider spread in damage ratios based on claims data at lower damageability portions of a curve, thus the larger CV.

CASE STUDY 1: VULNERABILITY IMPACTS

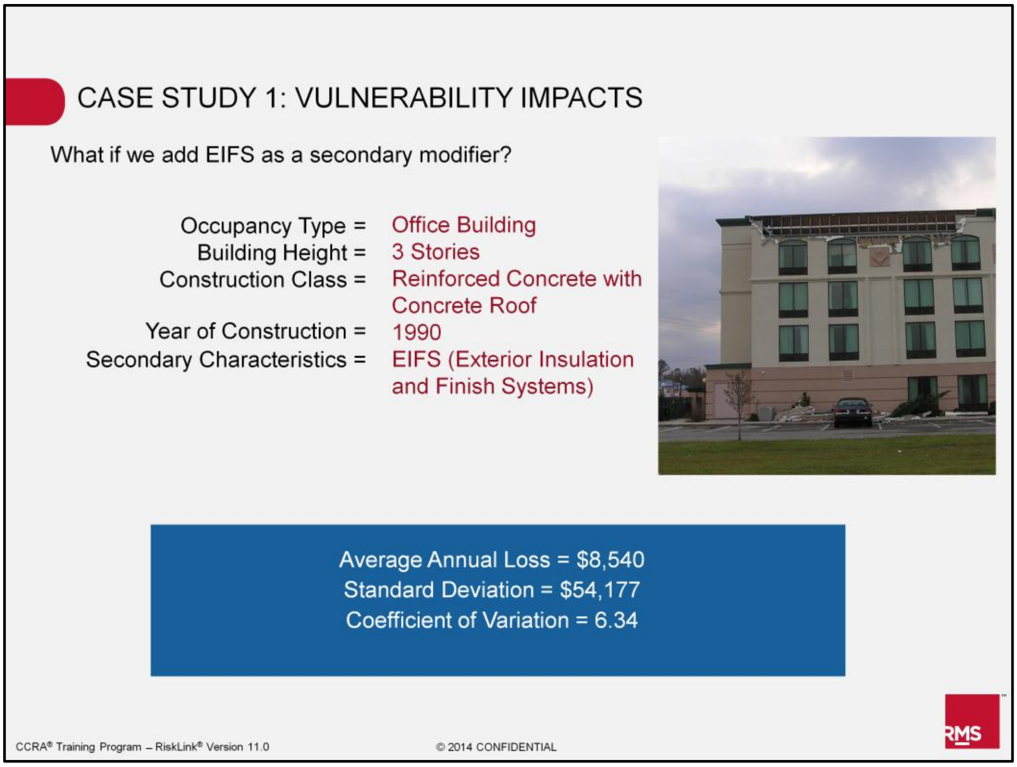
What if we add the year of construction to be 1990 instead of 2002?

Occupancy Type = Office Building
Building Height = 3 Stories
Construction Class = Reinforced Concrete with Concrete Roof
Year of Construction = 1990
Secondary Characteristics = Unknown

Average Annual Loss = $6,890
Standard Deviation = $46,166
Coefficient of Variation = 6.70

The loss estimate can be improved with more information.

If the building was built in 1990 instead of 2002, the resulting AAL increases as expected given the more vulnerable construction of older buildings. Additionally, the CV has decreased since the loss ratio for this building has increased – at higher wind speeds/loss ratios there is less variation of the estimate.

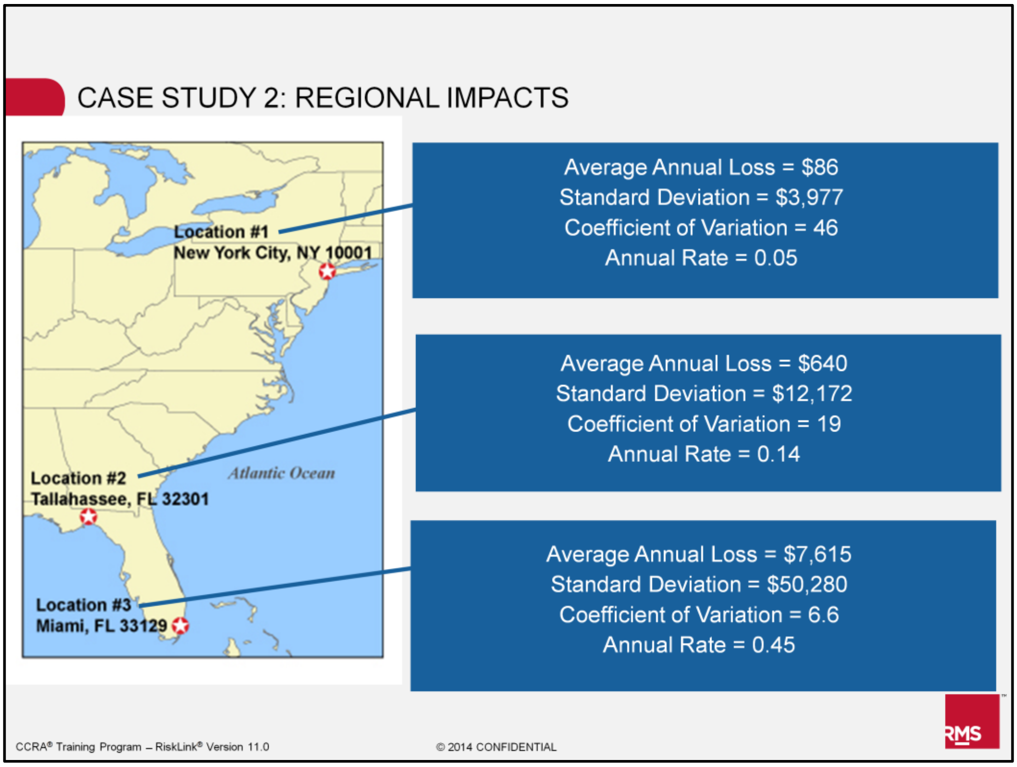


The portfolio-level vulnerability function for a specified combination of occupancy, construction class, year of construction, and height defines the vulnerability or damageability of an "average" building in the portfolio that encapsulates a wide range of building characteristics. Certain characteristics of a building can enhance or reduce its vulnerability to severe winds. The building vulnerability module in the RMS U.S. Hurricane Model quantifies the impact of these special building characteristics and/or mitigation measures on a building's vulnerability through the use of secondary modifiers that scale the portfolio-level average vulnerability function up or down.

For the final scenario in our first case study, we assume this office building cladding type contains an Exterior Insulation and Finish Systems, or EIFS. This type of cladding is one of the most vulnerable cladding types, and is reflected in the increase in AAL from $6,890 to $8,540. The CV has decreased from 6.70 to 6.34. This is a reflection of increased confidence in our results given the primary and secondary building characteristics have been defined. When you add modifiers to the program, the CV is decreased for each modifier added.

Due to the range in possible loss scenarios as a result of varying primary building characteristics, it is required in RiskLink to provide all primary building characteristic information before a secondary modifier will impact a loss assessment (occupancy, construction, year of construction, and number of stories). While square footage is considered a primary building characteristic for single family dwellings, it can be left unknown and secondary modifiers will still work for single family dwellings.

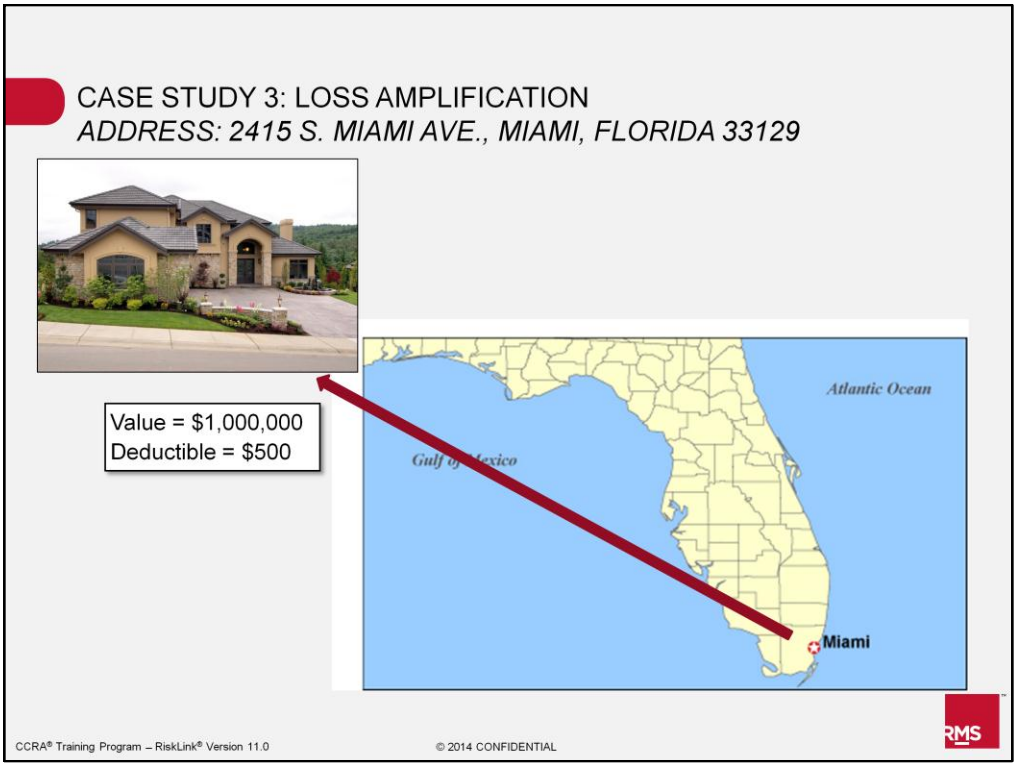
For example, if the year of construction was labeled as unknown, but EIFS was classified as a secondary characteristic, the losses would be identical to slide 14 (i.e., classifying EIFS would have no impact on the loss assessment, due to the unknown year of construction).



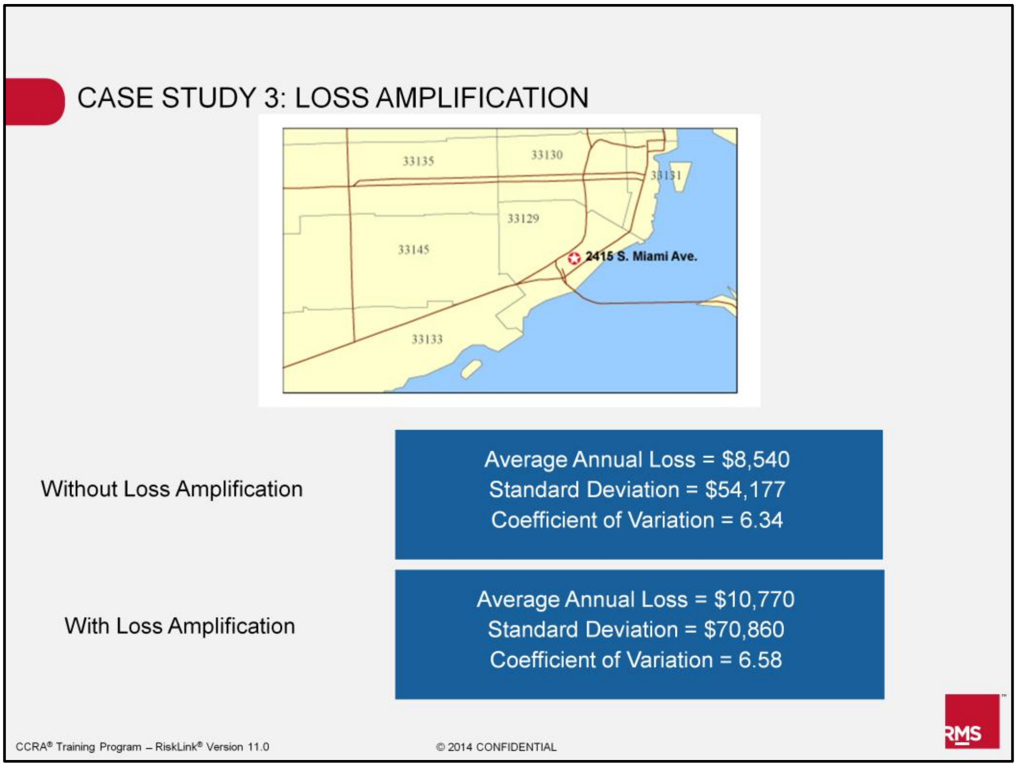
Case study two demonstrates regional impacts of hurricanes on the same building. Not all locations are subjected to the same tropical cyclone frequency and severity, and regional building codes will vary for the same type of construction. Therefore, it is the frequency and severity of the hazard that drives the differences noted on this slide, not the vulnerability of the building stock.

We have selected three ZIP Code geocoded locations: New York City, NY 10001; Tallahassee, FL 32301; and Miami, FL 33129. Miami, FL 33129 is the most vulnerable of these three locations with an AAL of $7,615. Miami, FL has an annual rate of hurricane occurrence of 0.45, or a return period of about two years of tropical storm force winds. Even locations that are within the same state can observe substantial differences in AAL. For example, Tallahassee is further inland than Miami and the AAL decreases to $640. Tallahassee has an annual rate of hurricane occurrence of 0.14 or a return period of seven years of tropical storm force winds. The least vulnerable of these locations is New York City, NY with an AAL of only $86 and an annual rate of 0.05, or a return period of 20 years of tropical storm force winds.

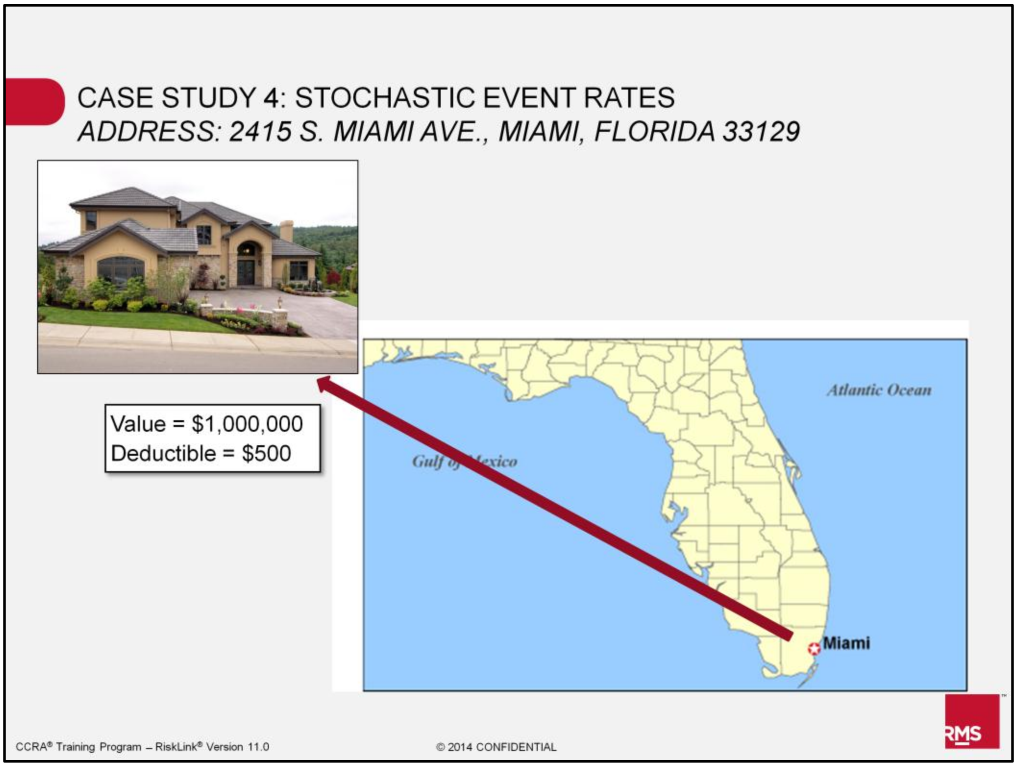
Note that in areas where the event probabilities are much lower, one would expect a larger range of uncertainty around the modeled loss.



The third case study illustrates the impact of loss amplification on loss, or the increase in normal cost of settlement due to a unique set of economic, social, and operational factors. Refer to the end of Unit 3 of this course for more information on loss amplification and how it is implemented in RMS catastrophe models. For this example, we will again use the same location in Miami, FL with an insured value of $1 million and a deductible of $500.

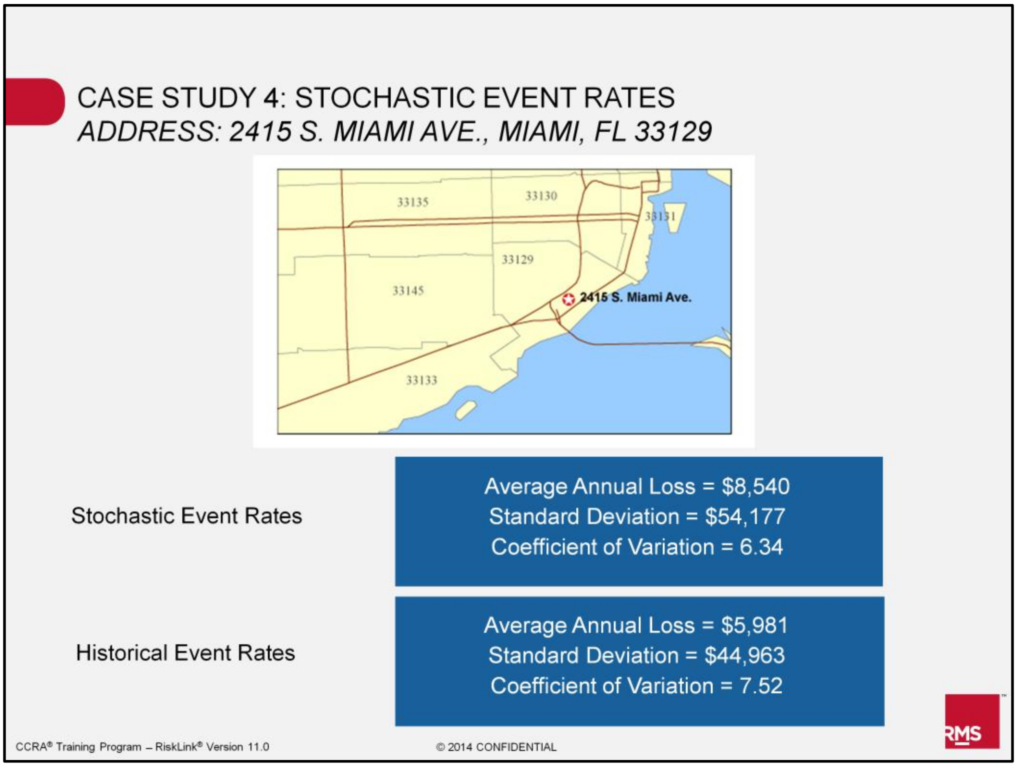


For our location, both the mean loss and the CV increase with the implementation of loss amplification. The inclusion of Super Cat scenarios is a driver of increased uncertainty, due to the larger potential range in loss outcomes as a result of secondary catastrophic losses following the catastrophic storm impacts of wind and storm surge.



The fourth and final case study illustrates the impact of using long-term historically-based event rates vs. the RMS stochastic event rates. The stochastic rates or medium-term rates reflect the expected annual activity averaged over the next five years. The medium-term are higher than the long term average rates and reflect the state of enhanced hurricane activity since 1995, and so lead to higher losses. Refer to Unit 2 of this course for more information on the development of tropical cyclone event rates and how they are implemented in RMS catastrophe models.

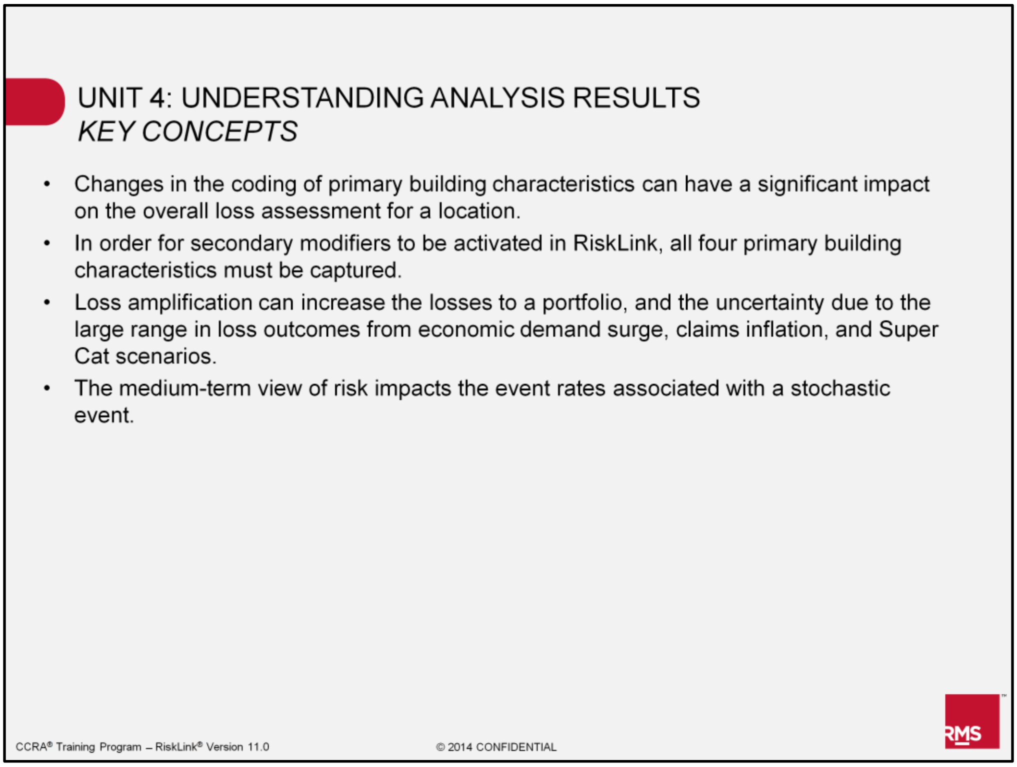
For this example, we will again use the same location in Miami, FL with an insured value of $1 million and a deductible of $500.



The stochastic event probabilities used in the U.S. Hurricane model are based on the latest scientific research, which indicates that U.S. hurricane landfalls from 2011–2015 will be higher than the long-term historical average. Based on the recent historical hurricane record, Atlantic hurricane activity has persisted since 1995. In 2004 and 2005, the high activity in the basin broke through to U.S. landfall creating high levels of insured losses. With strong evidence that higher than average activity rates are likely to persist for at least a decade, it is no longer appropriate to employ a long-term historical baseline for characterizing medium-term activity rates in hurricane catastrophe models.

Since the stochastic event rates include higher than average storm activity rates relative to the long-term historical baseline, the location in Miami, FL shows AAL increasing by $2,500 when using the stochastic event rates instead of the historical event rates. Note: AAL = sum (event mean loss * event rate), thus if the event rates increase, so does the AAL.

With a significant increase in AAL, relative to the increase in standard deviation, the CV for the stochastic event rates analysis decreases. This is a reflection of greater certainty in the structural response for higher severity events, which have a greater frequency in the stochastic storm set.



This slide highlights the key points from Unit 4 of this course. We encourage you to review these topics to ensure that you have a good understanding of each bulleted item before proceeding to Unit 5 on post-event loss modeling.

This concludes Unit 4 of the Tropical Cyclone Modeling course presentation.