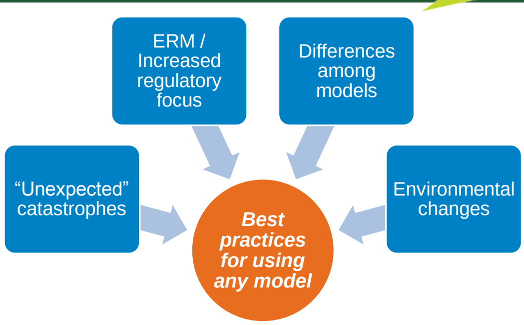
CS-19
Using Models with Uncertainty

Susan R. Curtis, Ph.D., FCAS
AIR Worldwide

Antitrust Notice

- The Casualty Actuarial Society is committed to adhering strictly to the letter and spirit of the antitrust laws. Seminars conducted under the auspices of the CAS are designed solely to provide a forum for the expression of various points of view on topics described in the programs or agendas for such meetings.
- Under no circumstances shall CAS seminars be used as a means for competing companies or firms to reach any understanding – expressed or implied – that restricts competition or in any way impairs the ability of members to exercise independent business judgment regarding matters affecting competition.
- It is the responsibility of all seminar participants to be aware of antitrust regulations, to prevent any written or verbal discussions that appear to violate these laws, and to adhere in every respect to the CAS antitrust compliance policy.

Model Uncertainty Highlights the Importance of Following Best Practices

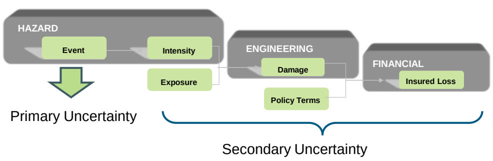


Agenda

- Understand different definitions of uncertainty
- Develop intuition for uncertainty in catastrophe models
- Evaluate reasonability of model results

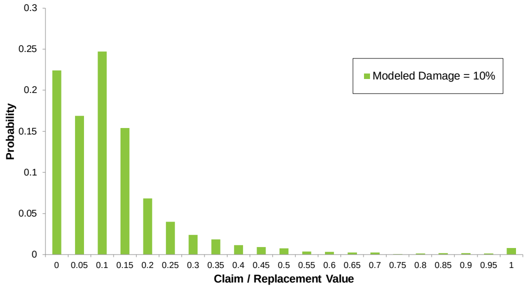
Model Components Involve Different Types and Definitions of Uncertainty

- Traditional actuarial view
  - Process risk
  - Parameter risk
  - Model risk
- Cat modeling firm view



Secondary Uncertainty: Adjacent Similar Structures Often Have Very Different Levels of Damage

Secondary Uncertainty Leads to a Probability Distribution of Claims



There Are Many Sources of Uncertainty to Consider for Historical Events

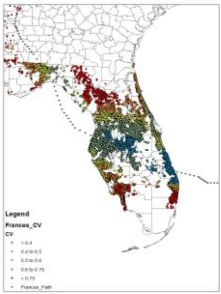
- Uncertainty in event parameters
- Uncertainty in local intensity even if event parameters are known
- Uncertainty in construction: type, quality, secondary modifiers, potential data errors
- Uncertainty in replacement value
- Uncertainty in cost to repair
- Uncertainty in coverage / claims practices

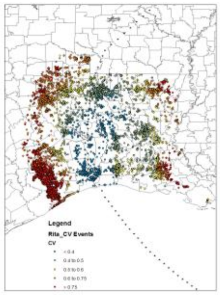
Uncertainty from Event Parameters

Consider the following experiment:

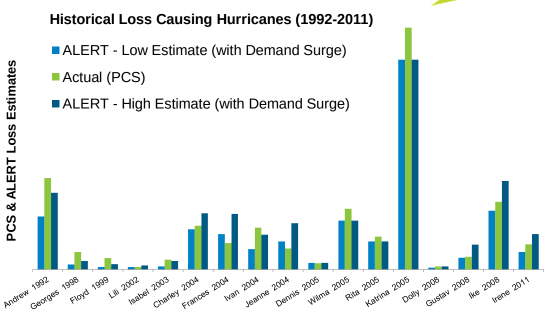
- Start with historical event parameters (e.g., Frances, Rita)
- Vary key event parameters over “reasonable” range of uncertainty to create many new hypothetical events
  - Parameters varied:
    - Radius of maximum winds (Rmax) +/- 10%, 20%
    - Peripheral pressure (PP) +/- 4mb
    - Wind reduction factor (GWRF) +/- 0.02
  - Factorial design (all combinations)
- Rerun AIR CLASIC/2 on these new events
- Compare predicted losses among hypothetical events

Uncertainty in Losses from Two U.S. Hurricanes



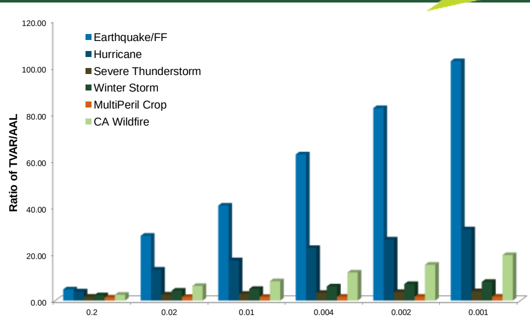


Uncertainty in Real-Time Historical Event Losses

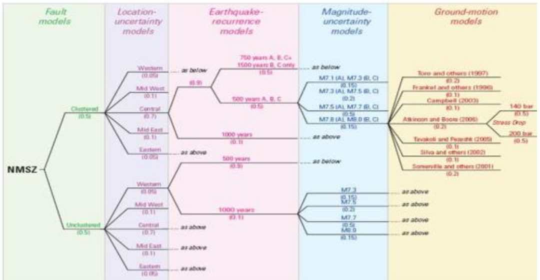


ALERT: Low & high estimates for Hurricanes Dennis, Wilma, Rita, and Katrina represent the single, final loss estimate for each storm and not a range of (low-to-high) losses.

Relative Uncertainty of Different Perils (Primary/Process Uncertainty)



Scientific View of Earthquake Uncertainty

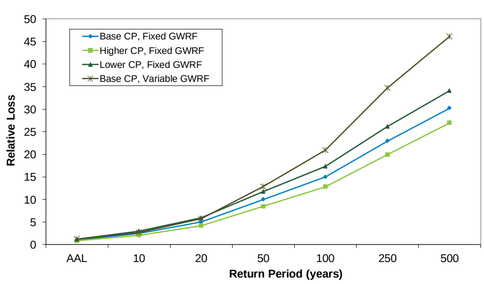


Source: USGS

Catalog Uncertainty Study for Florida Hurricanes

- Generate new 50k catalogs by changing assumptions on two key parameters
  - Adjust all events to have higher or lower Central Pressure (CP) by one standard error of mean from historical data
  - Compare fixed and variable Gradient Wind Reduction Factor (GWRF ~ N(.9,0.08))
- Run AIR CLASIC/2 with new catalogs to estimate new Florida industry losses under a variety of scenarios
- Compare with losses from base catalog at various points on the Exceedance Probability curve

Simulated Florida Hurricane Losses with Adjusted Catalogs



Other Sources of Uncertainty

- Data Quality (worth an entire presentation on its own)
  - Replacement values
  - Construction
- Possible Trends
  - Global warming?
  - Global earthquake trends?
- Others
  - Earthquake faults we don't know about or underestimate
  - Event clustering we don't know about or underestimate
  - Events that cause structural failures (e.g. levees)
  - Politics and legal issues
  - Claims settlement procedures

ASOP 38: Using Models Outside of the Actuary's Area of Expertise (from 2011 draft)

- Evaluate the appropriateness of the model for the intended use
  - Assumptions / parameters / limitations
- Review the model (or rely on a review by another actuary)
  - Model components
  - Review and testing by experts
  - Evaluate user data and assumptions for reasonableness
  - *Evaluate model output for reasonableness*
    - *Comparison with actual historical experience*
    - *Sensitivity to variations in user input*
    - *Overall reasonableness based on … professional judgment*

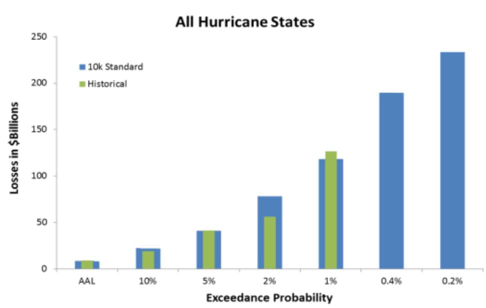
Validating Models and Testing for Reasonableness

- Real-time loss validation
  - Provides test data not used in training the model
  - But note this validates some components only
- Industry and company loss validation
  - Losses over a longer time period can help validate catalog
    - But note that trending historical data is non-trivial
  - Individual company losses can provide additional validation
    - But understand differences between modeled and actual losses
- Frequency validation

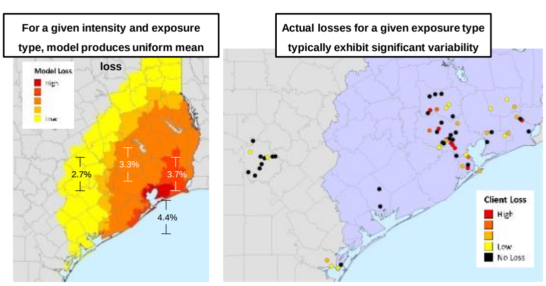
Check Key Historical Losses and Associated Return Periods for Reasonability

Year	Name	Loss [$B USD]	Return Period	Exceedance Probability
1926	Great Miami	126	121	0.8%
1992	Andrew	55	30	3.3%
1947	Fort Lauderdale FL	52	27	3.7%
1928	Great Okeechobee	49	25	4.0%
1965	Betsy	40	20	5.0%
2005	Katrina	39	20	5.0%
1900	Galveston	39	19	5.3%
1960	Donna	33	16	6.3%
1938	Great New England	33	15	6.7%

Compare AAL and Short-term Exceedance Probabilities to Historical Record



Validating the Model with Actual Claims Data



Ensure Consistency Between Modeled and Observed Losses

Modeled Perils

- Wind (includes direct wind, and implicitly includes damage from wind debris, wind-driven rain and tree failure)
- Storm surge

Modeled Coverages

- Coverage A - Dwelling
- Coverage B - Other Structures
- Coverage C - Contents / Personal Property
- Coverage D - Additional Living Expense / Business Interruption

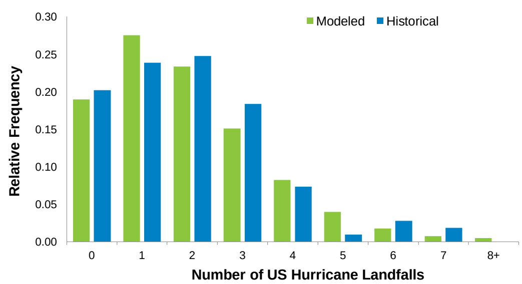
Non-Modeled Perils

- US riverine or hurricane-induced flooding
- Loss from levee or dam failures
- …

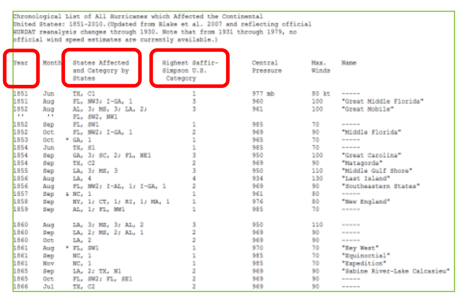
Non-Modeled Loss Components

- Loss adjustment expenses
- Hazardous waste removal
- Loss inflation due to political pressure
- …

Validating Frequency Distributions



U.S. Hurricane Data is Readily Available Online


Chronological List of All Hurricanes which Affected the Continental United States: 1851-2010. (Updated from Blake et al. 2007 and reflecting official HURDAT reanalysis changes through 1930. Note that from 1931 through 1979, no official wind speed estimates are currently available.)

Year	Month	States Affected and Category by States	Highest Saffir-Simpson U.S. Category	Central Pressure	Max. Winds	Name
1851	Jun	TX, C1	1	977 mb	80 kt	-----
1851	Aug	FL, NW3; I-GA, 1	3	960	100	"Great Middle Florida"
1852	Aug	AL, 3; MS, 3; LA, 2;	3	961	100	"Great Mobile"
''	''	FL, SW2, NW1				
1852	Sep	FL, SW1	1	985	70	-----
1852	Oct	FL, NW2; I-GA, 1	2	969	90	"Middle Florida"
1853	Oct	* GA, 1	1	965	70	-----
1854	Jun	TX, S1	1	985	70	-----
1854	Sep	GA, 3; SC, 2; FL, NE1	3	950	100	"Great Carolina"
1854	Sep	TX, C2	2	969	90	"Matagorda"
1855	Sep	LA, 3; MS, 3	3	950	110	"Middle Gulf Shore"
1856	Aug	LA, 4	4	934	130	"Last Island"
1856	Aug	FL, NW2; I-AL, 1; I-GA, 1	2	969	90	"Southeastern States"
1857	Sep	& NC, 1	1	961	80	-----
1858	Sep	NY, 1; CT, 1; RI, 1; MA, 1	1	976	80	"New England"
1859	Sep	AL, 1; FL, NW1	1	985	70	-----
1860	Aug	LA, 3; MS, 3; AL, 2	3	950	110	-----
1860	Sep	LA, 2; MS, 2; AL, 1	2	969	90	-----
1860	Oct	LA, 2	2	969	90	-----
1861	Aug	* FL, SW1	1	970	70	"Key West"
1861	Sep	NC, 1	1	985	70	"Equinoctial"
1861	Nov	NC, 1	1	985	70	"Expedition"
1865	Sep	LA, 2; TX, N1	2	969	90	"Sabine River-Lake Calcasieu"
1865	Oct	FL, SW2; FL, SE1	2	969	90	-----
1866	Jul	TX, C2	2	969	90	-----

http://www.aoml.noaa.gov/hrd/hurdat/All_U.S._Hurricanes.html

How Are AIR's Clients Dealing with Uncertainty?

- More focus on understanding various vendors' results
  - Validation
  - Strategies for combining results
- More focus on sensitivity analysis
  - How would output change with different frequency assumptions?
  - How would output change with different damage functions?
- More focus on extreme "deterministic" scenarios
  - Many companies already assess terrorism risk this way
  - Some organizations already use fixed events (RDS)
  - Can include hypothetical events with very low frequency

Catastrophe Model Users Are Not Alone!

- "All models are wrong, but some models are useful"
  - George E. P. Box, statistician
- "Prediction is very difficult, especially about the future"
  - Niels Bohr, Danish physicist
- "One must never forget that models are not the world"
- "You must start with models and then overlay them with common sense and experience"
  - E. Derman & P. Wilmott, *Financial Modeller's Manifesto*

Summary

- Key components to effective use of models
  - Understand different definitions of uncertainty
  - Develop intuition for uncertainty in results
  - Evaluate reasonability of model results
- Users of model output must "own" their risk
  - Apply your industry experience to critically evaluate models
  - Never blindly accept model output
  - Never be afraid to ask questions of model vendors