Keeping Up with the CAT Models

Applications of ASOP 38 to Wildfire and Flood Models

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Agenda

Keeping Up with the CAT Models

1. Catastrophic Perils – Wildfire and Flood
2. Catastrophe Model Basics
3. Wildfire and Flood Catastrophe Model Components
4. ASOP 38 Considerations
5. Closing

Antitrust Notice

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Wildfires

Overview

- A **wildfire**, or **wildland fire**, is a sweeping and destructive conflagration especially in a wilderness or a rural area
- Unlike hurricanes and earthquakes, wildfires can be ignited by both natural and human sources, and property damage could be largely mitigated by human intervention.
- Wildfires can be large and yet have no property damage, or small but have devastating property damage
  - Mendocino Complex 2018: 280 structures / 460,000 acres burned
  - Oakland Hills 1991: 2,900 structures / 1,600 acres

California Camp Fire (2018)
Source: NASA Landsat 8 Operational Land Imager

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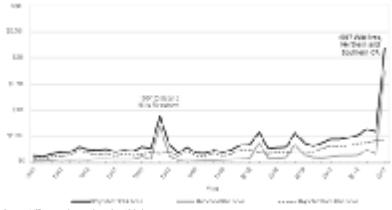
Why Use Wildfire CAT Models?

Volatility of Historical Data

- Wildfire insured loss experience can be highly volatile, rendering historical loss data potentially unreliable.



Source: Milliman estimates, based on ISO data

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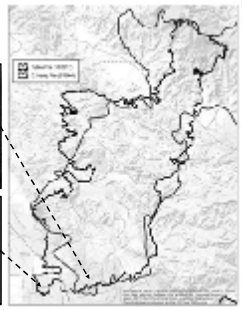
Why Use Wildfire CAT Models?

Long Term Shifts toward

- Wildfire risk has been increasing due to housing developments in the wildland-urban interface (WUI)
- The 2017 Tubbs Fire in Northern California burned through entire neighborhoods that had been built since the 1960s.



Sources: *The Press Democrat, Sonoma Magazine*

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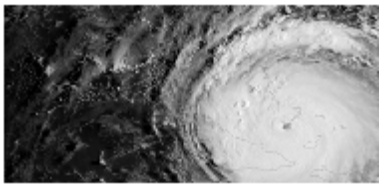
Types of (catastrophic) floods



- **Storm Surge**
- Inland Flood
- Tsunami

Source: NOAA

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Types of (catastrophic) floods

- Storm Surge
- **Inland Flood**
- Tsunami

Source: *The Mercury News*

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Types of (catastrophic) floods

- Storm Surge
- **Inland Flood**
- Tsunami

Source: USGS

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Types of (catastrophic) floods

- Storm Surge
- Inland Flood
- **Tsunami**

Source: *Deep Impact* (1998)

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What is driving the advances in flood catastrophe models?

- Computing power
- Historical data limitations
- Climate change
- Demand for flood insurance options

Image source: *Houston Chronicle*

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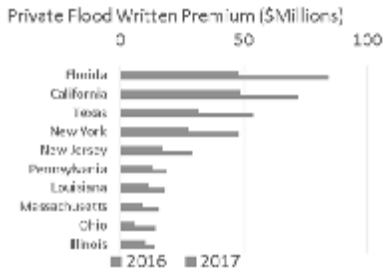
Growth in private flood market



Source: Insurance Journal.
Originally reported by S&P Global

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Why Use CAT Models?

Summary

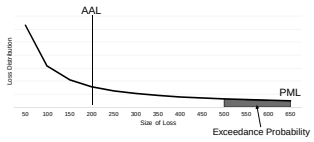
1. Historical data may not represent the future
2. Advances in computing power make fully probabilistic models more accessible
3. Climate change / extreme weather increasingly affecting risk attitudes
4. Growth in private flood market / demand for homeowner's insurance in wildfire-exposed areas

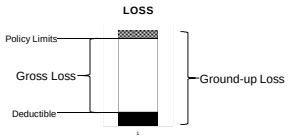
§ Therefore, CAT models are more relevant now than ever

Catastrophe Model Basics

Uses

§ Fully probabilistic catastrophe models can be used to compute:
  § Average annual loss (AAL) – expected loss per year, averaged over many years
  § Probable maximum loss (PML) – value of the largest loss that could result from a disaster
  § Gross loss – losses *after* accounting for policy limits and deductibles
  § Ground-up loss – losses *before* accounting for policy limits and deductibles
  § Annual loss distributions
  § Event-level impacts to subsets of policyholders
  § Calculate exceedance probabilities





Catastrophe Model Basics

Uses

§ Uses of catastrophe models:
  § Pricing for primary insurers, reinsurers, and catastrophe bonds
    § Overall rate levels
    § Segmentation at varying granularity levels
  § Underwriting / risk selection
  § Loss mitigation strategies / disaster planning
  § Portfolio management
  § Enterprise Risk Management

Catastrophe Model Basics

Typical Components

1. Hazard

Simulates the catastrophic risk based on scientific knowledge

2. Inventory

Contains detailed information about the properties (or risks), such as insured value, construction type, location, etc.

3. Vulnerability

Determines damage at the individual risk level by combining results from the hazard and inventory components

3. Loss

Calculates the insured loss based information from the vulnerability module and the applicable policy limits and deductibles

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Typical Components of a Wildfire Model

1. Fire Ignition (Hazard)
2. Fire Spread (Hazard)
3. Fire Suppression (Hazard)
4. Vulnerability
5. Loss

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Causes of Wildfire

Fire Ignition

Lightning

Fallen Power Lines

Intentional Arson

Stupid Arson

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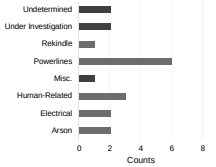
Causes of Wildfire

Fire Ignition

- Natural causes have not yet been determined to be the cause of any of the top 20 most destructive wildfires in California



Cal Fire

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Determinants of Wildfire Risk

Fire Ignition and Fire Spread - Fuel

- Fuels

Forest

- High fuel load
- Difficult for firefighters to traverse

Grass

- Quick to lose moisture in drought
- Low fuel load

Building Structures

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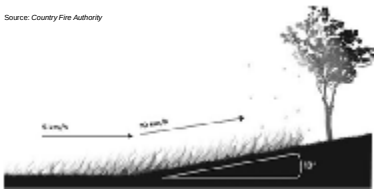
Determinants of Wildfire Risk

Fire Ignition and Fire Spread – Topography / Terrain

Source: *Country Fire Authority*



- Slope affects the speed of fire spread
- Aspect (direction that the slope faces) affects vegetation moisture
- Canyons, cliffs, and other natural formations can impede or exacerbate fire spread

Cal Fire

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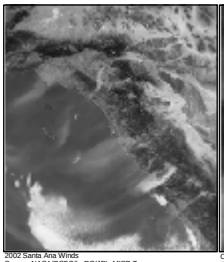
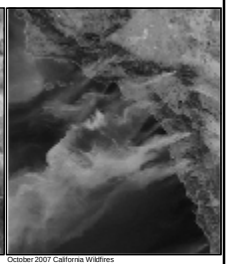
Determinants of Wildfire Risk

Fire Ignition and Fire Spread - Climate

- Katabatic Winds (Santa Ana / Diablo / Sundowner winds) are fast, hot, dry winds associated with some of California's most destructive fires:
  - October 2007 California Wildfires
  - 1991 Oakland Hills Fire
- Wind speed and direction
- Temperature and humidity



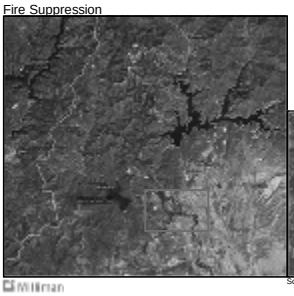
2002 Santa Ana Winds
Source: NASA/GSFC/LaRC/JPL, MISR Team



October 2007 California Wildfires
Source: NASA

Determinants of Wildfire Risk

Fire Suppression

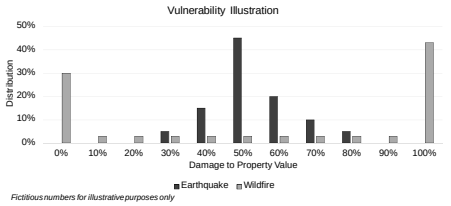


- Fire suppression can highly influence whether or not a house is a total burn.
- The Carr Fire (2018) (depicted) stopped short of starting a massive urban conflagration

Source: CAL Fire

Wildfire Loss

Vulnerability



Fictitious numbers for illustrative purposes only

- In the event of a wildfire, property losses tend to face either no loss or total loss, with fewer cases in-between.
- Unlike other perils, property losses from wildfires exhibit a bimodal distribution.

Wildfire Loss

Vulnerability and Damage

- Building materials
  - Property construction type
  - Fire-resistant roof materials
  - Fire-resistant wall siding
- Mitigating features such as:
  - Defensible space
  - Fire/Ember-resistive vents

Source: *Associated Press*

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Flood catastrophe models

AIR

KatRisk

CoreLogic

AON Empower Results®

RMS

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Hazard module elements within flood cat models

Inland Flood

- Hydrology
- Hydraulics
- Protection

Source: USGS

Storm Surge

- Tropical storm model
- Coastline
- Tidal variability
- Topography / bathymetry
- Protection

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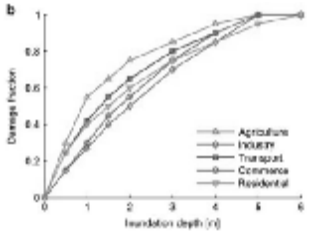
Vulnerability module elements within flood cat models

Inland Flood / Storm Surge
§Depth damage curves §Property characteristics §Flow velocity §Mold §Other coverages



Source: "Damage and protection cost curves for coastal floods within the 600 largest European cities", *Scientific Data*

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ASOP 38 Considerations

1. Determine appropriate reliance on experts
2. Have a basic understanding of the model
3. Evaluate whether the model is appropriate for the intended application
4. Determine that appropriate validation has occurred
5. Determine the appropriate use of the model

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1. Determine appropriate reliance on experts

- § Are the individuals being relied upon considered experts?
- § Has the model been reviewed by experts in the applicable field? Are there significant differences of opinion concerning model aspects?
- § Are there standards that apply to model or its testing/validation? Has the model been certified as having met these?

Florida Commission on Hurricane Loss Projection Methodology

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2. Have a basic understanding of the model

- Model components
- User input
- Model output

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2. Have a basic understanding of the model
How does the model treat certain policy / property characteristics?

- Basements
- Foundation type
- Year built
- Construction type
- Number of stories
- Other coverages

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2. Have a basic understanding of the model
Understand outputs

- Average annual loss
- Annual loss variability?
- Flood depths
- Excluded perils (e.g. coastal erosion, lahar)

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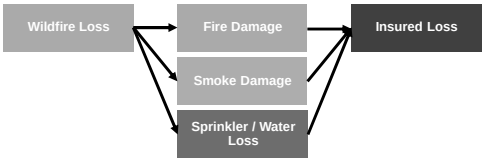
2. Have a basic understanding of the model

Basic Model Understanding

- What perils are included in the model?



- Related: What wildfire events are included in the model?
  - e.g. any damage-causing events; events with losses in excess of dollar or structure count thresholds

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2. Have a basic understanding of the model

Basic Model Understanding

- User inputs and model detail
  - What are the required user inputs for the model?
  - What optional inputs are supported by the model?
  - Are property characteristics sufficiently detailed for the model?
  - What characteristics are assumed by the model if unknown?
  - What is the model resolution?

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3. Evaluate whether the model is appropriate for the intended application

- Scenario: Wildfire catastrophe model does not support risk-level mitigation features
  - Possibly appropriate for overall catastrophe load for rate indications
  - Likely inappropriate for determination of wildfire mitigation discounts
- Scenario: Wildfire catastrophe model does not include coverage detail (e.g. dwelling vs. contents losses)
  - Inappropriate for modeling wildfire losses for contents-only coverage
- Scenario: Wildfire catastrophe model does not model damages arising from smoke losses
  - May be appropriate for overall catastrophe load for rate indications with adjustments for smoke losses

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4. Determine that appropriate validation has occurred

- User input
- Model output
  - Alternate models or methods
  - Historical observations
  - Consistency / reasonableness of relationships among results
  - Sensitivity

4. Determine that appropriate validation has occurred

- Maps can be used to validate reasonability of modeled wildfire risk. Features that can be mapped and compared:
  - Historical wildfire perimeters
  - Fuel / vegetation
  - Topographic
  - Wildland Urban Interface/Intermix
- Average annual loss can be plotted against risk characteristics to determine reasonability and consistency, such as:
  - Distance to nearest high risk wildfire zone
  - Mitigation features
  - Construction type
  - Road accessibility
  - Other wildfire risk model scores or AALs

Source: *CAL FIRE*

4. Determine that appropriate validation has occurred

- Compare results from alternate models or methods
- Consistency and reasonableness of relationships among various output results

Distance from Wildland	Model 1 Average Annual Loss	Model 2 Average Annual Loss	Model 3 Average Annual Loss
0 to 30 ft.	400	200	500
30 to 100 ft.	400	200	300
100 to 500 ft.	100	200	100
500 to 1000 ft.	100	200	50

4. Determine that appropriate validation has occurred
Test model using a market basket

- Allows analysis where in-force data may be thin or non-existent
- Actual risk locations
- For other characteristics, realistic distributions

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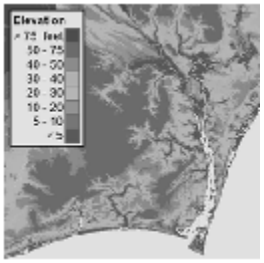
4. Determine that appropriate validation has occurred
Add geographic characteristics

- **Elevation**
- Relative elevation
- Distance to coast
- Distance to river
- Size of river
- Hydrological features/watersheds
- Slope
- Flood protection and levees



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4. Determine that appropriate validation has occurred
Add geographic characteristics

- Elevation
- **Relative elevation**
- Distance to coast
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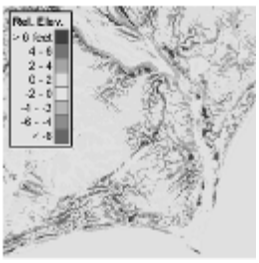

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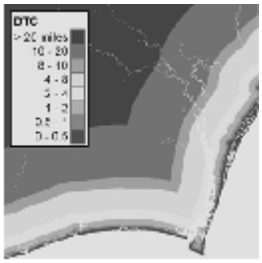
4. Determine that appropriate validation has occurred

Add geographic characteristics

§ Elevation
§ Relative elevation
§ **Distance to coast**
§ Distance to river
§ Size of river
§ Hydrological features/watersheds
§ Slope
§ Flood protection and levees



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4. Determine that appropriate validation has occurred

Add geographic characteristics

§ Elevation
§ Relative elevation
§ Distance to coast
§ **Distance to river**
§ Size of river
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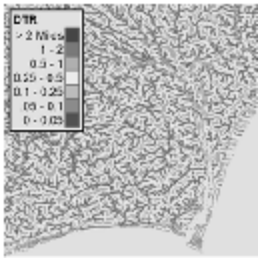

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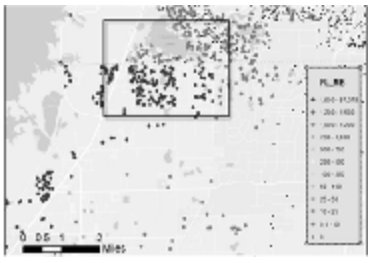
4. Determine that appropriate validation has occurred



§Plot results
§Discontinuities
§$0 AALs
§Illogical results

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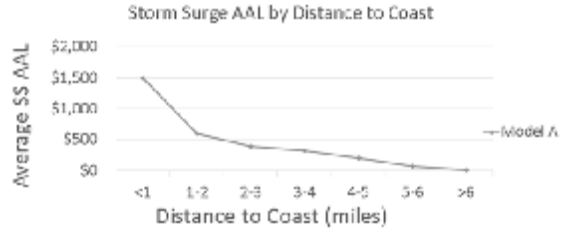
4. Determine that appropriate validation has occurred
Consistency / reasonability and sensitivity



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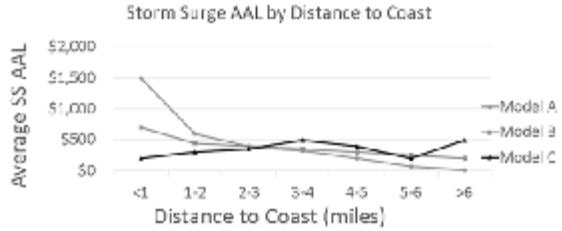
4. Determine that appropriate validation has occurred
Consistency / reasonability and sensitivity



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4. Determine that appropriate validation has occurred
Which models are most reasonable?

Beach House

Model X	Model Y	Model Z
$1,000	$30	$20,000

Inland Property

Model X	Model Y	Model Z
$1,500	$3	$30

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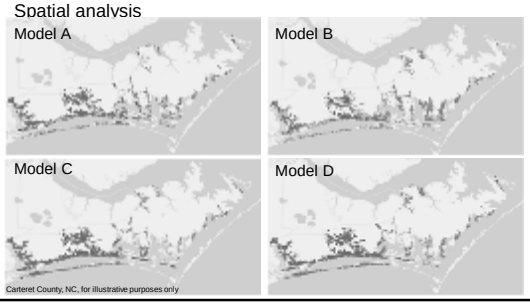
4. Determine that appropriate validation has occurred

Spatial analysis



Carteret County, NC, for illustrative purposes only

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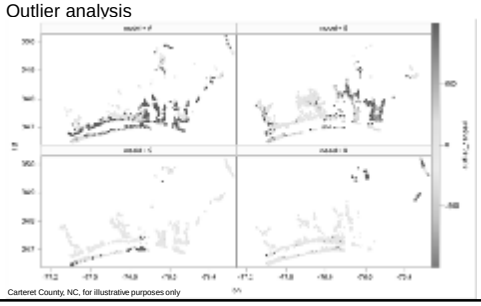
4. Determine that appropriate validation has occurred

Outlier analysis



Carteret County, NC, for illustrative purposes only

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4. Determine that appropriate validation has occurred

	Percent missing AAL	Percent zero AAL	Small Outliers	Large Outliers
Model A	0%	19%	70%	4%
Model B	11%	1%	16%	7%
Model C	0%	0%	1%	16%
Model D	0%	0%	2%	45%

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4. Determine that appropriate validation has occurred
Comparison to historical results

	Hurricane X	River Flood Y	Tropical Storm Z
Model A	$5 – 7B	$50 – 150M	$1 – 2B
Model B	$500M	$2B	$20B
Model C	$120B	$5 – 6B	$3 – 3.5B
Model D	$9 – 10B	$1B	$3 – 4B
Actual	$10B	$900M	$3B

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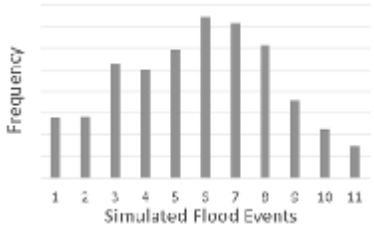
4. Determine that appropriate validation has occurred
Comparison to historical results



- Model documentation contains event catalog statistics
- Frequency (by season, region, etc.)

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5. Determine the appropriate use of the model

- Market analysis
- Underwriting
- Rate development

Source: NOLA.com

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5. Determine the appropriate use of the model

Rate development options

Low — Matching of Premium to Modeled Loss — High

NFIP Clone	Refined Rating Plan	Grid Rating Plan	Risk-Level Modeling

Low — Confidence in Model — High

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5. Determine the appropriate use of the model

- Professional judgment
- Appropriate adjustments
- Disclosures

ASB
Actuarial Standards Board

Actuarial Standard of Practice No. 41

Actuarial Communications

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Closing

- ASOP 38 **requires** documentation of the five steps above regardless of legal/regulatory requirements.
- An actuary may rely on another actuary's ASOP 38 evaluation, as long as the relying actuary is satisfied that the evaluation is performed according to ASOP 38. **Documentation of any such reliance is required.**

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Thank you

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