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Catastrophe Model Evaluation: Best Practice

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This meeting is being conducted in accordance with Institute's Code of Conduct and attended by members in their professional capacity.

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Participants are, therefore, reminded that in accordance with their competition law compliance obligations they should not:

- discuss any matter that may be perceived as being cooperation by competitors in a market to influence that market;
- discuss any matters that could be regarded as fixing, maintaining or controlling prices, allocation of customers or territories, coordinating bids and/or restricting output or acquisitions in any circumstances;
- share commercially sensitive information relating to their employer; or
- share information for an anti-competitive purpose.

Overview

Aim of this Session

To give actuaries insight into catastrophe model evaluation so they can:

(a) Have confidence and understand uncertainties in model output

(b) Make suitable decisions based on model output

(c) Learn about recent developments in next generation cat models.

Agenda

- Purpose and Users of Cat Model Evaluation
- Best Practice Principles
- Model Calibration Options

- Case Studies:
  - Tail issues - Chrissy Jung
  - High Frequency issues - Steven Zhu

- Extension: New generation of model outputs – Chrissy Jung

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Introduction

Model Evaluation: Purpose and Users

Give confidence that the catastrophe View of Risk is suitable to make decisions on capital and reinsurance.

Why Evaluate Catastrophe Models?

Confidence at an *Industry* Level

- Encourage transparency from model vendors
- Justifiable outcomes for our customers
- Reduce uncertainty in reinsurance purchasing

Confidence at a *Company* Level

- Adequacy of catastrophe allowance
- Adequacy of reinsurance
- Fairness in allocation

Issues

- Divergence of competing models
- Limited loss experience
- Unknown return period of large losses
- Wide uncertainty of modelled losses critical for decision making

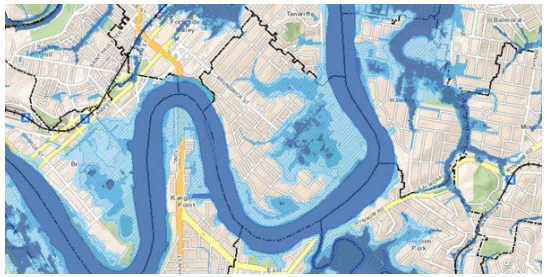
Users of Model Evaluation Reports

- Exposure and Accumulation management
- Capital team and rating agencies
- Reinsurance strategy, placement, allocation
- Business planning
- Pricing
- Underwriting strategy
- Event response/loss estimation

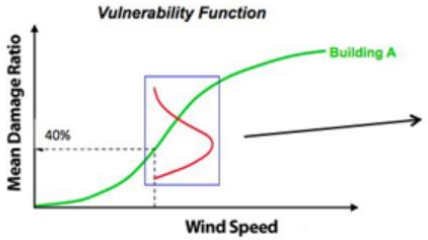
Structure of a Catastrophe Model

Risk = Hazard x Exposure x Vulnerability

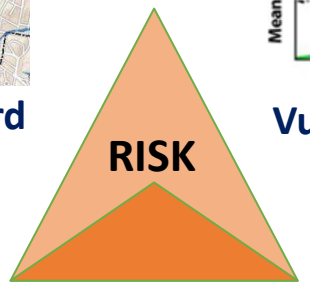
- Stochastic event set
- Hazard footprints
- Exposure inputs
- Vulnerability functions
- Financial module



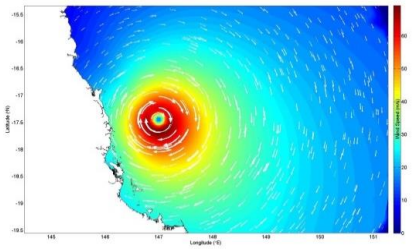
Hazard

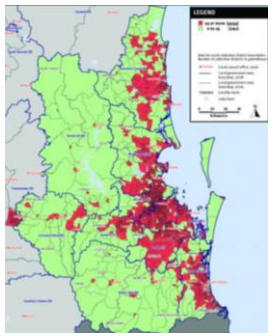


Vulnerability



Exposure





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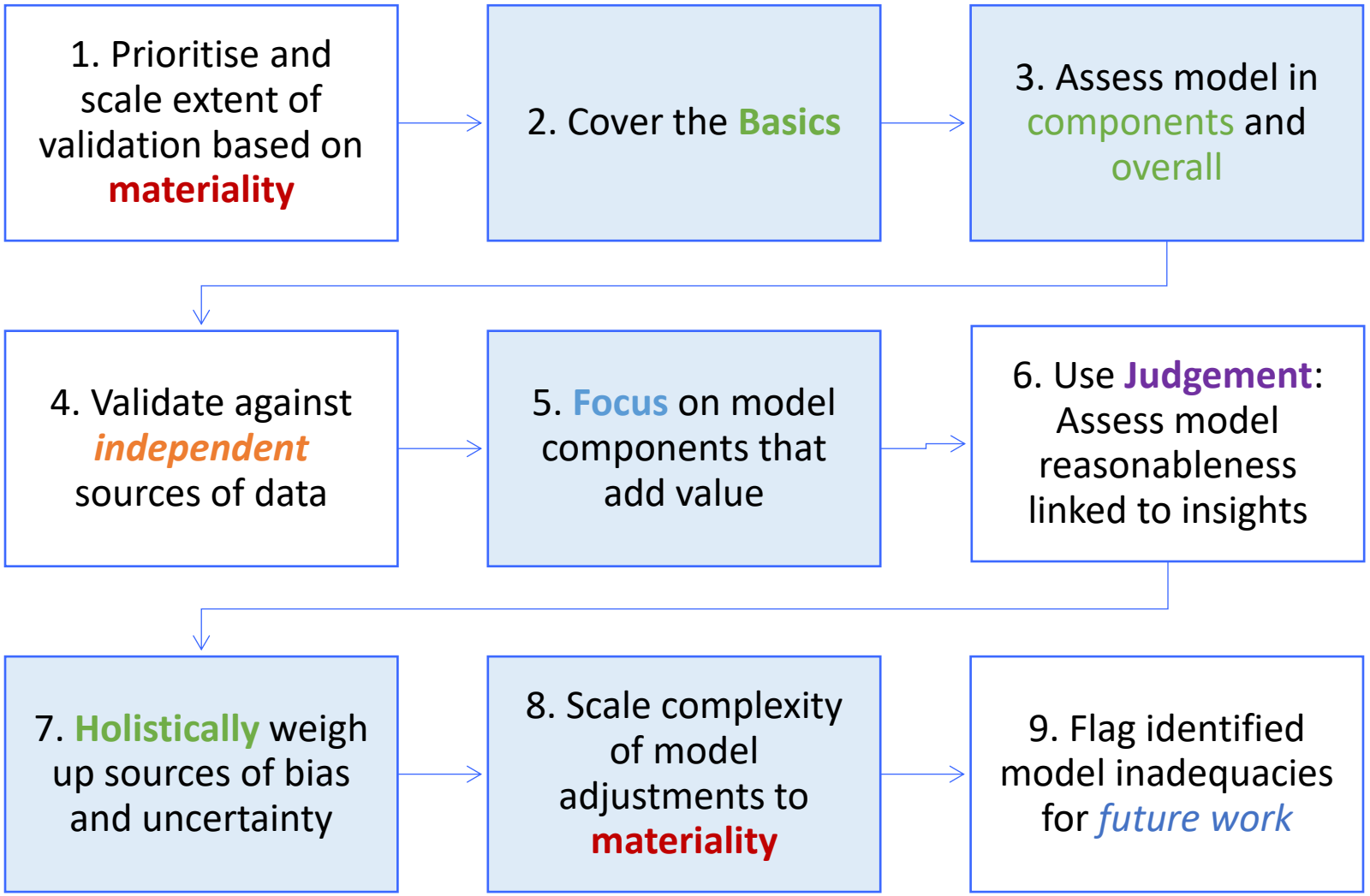
Cat Model Evaluation: Best Practice Principles

Aim: To assess suitability and adequacy of catastrophe models for our business.



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Model Evaluation Process

Aim: To assess suitability and adequacy of catastrophe models for our business.

Steps	Appendix	Governance	Operational Suitability
☐ Options Analysis	☐ Model Method Review	☐ Documentation	☐ Licence Cost
☐ Exposure Evaluation	☐ Financial Module Assessment	☐ Review: 1/2/3	☐ Run Time
☐ Impact Assessment	☐ Vulnerability Breakdowns	☐ Make Recommendation	☐ Data size and formats
☐ Hazard Assessment		☐ Seek Approval	☐ Data quality
☐ Vulnerability Assessment			☐ Training
☐ Loss Evaluation			
☐ Summary and Limitations			
☐ Recommendation			

! All Examples are Conceptual !

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Best Practice Principles

Principle 2: Cover the Basics

Clearly summarise the model change impact and coverage of your exposure.

Summarise Key Metrics

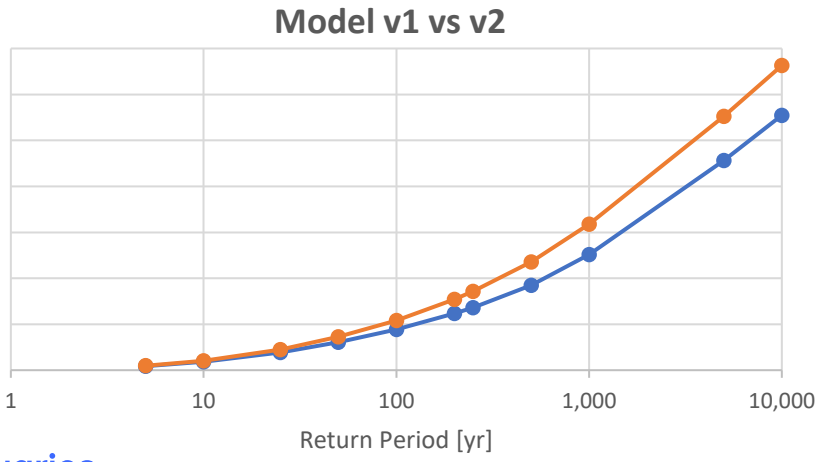
- Exposure
- AAL and EP curve
- Impact of model change

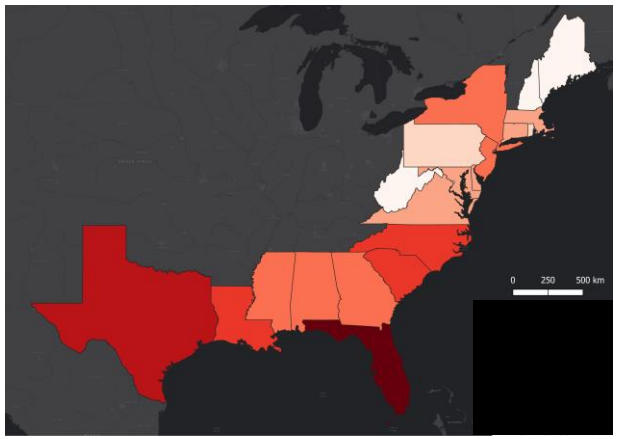
Functionality

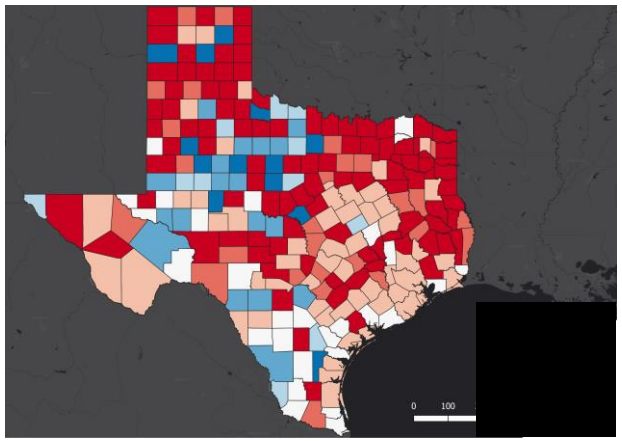
- **Coverage:** geographical, peril cause of loss, exposure class
- **Does it work?** EG does it apply defences, policy conditions etc

Define Appropriate Model Settings

- EG post loss amplification
- EG subperil selection







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Principle 3: Assess model in components and as a sum of its parts.

Hazard x Vulnerability x Exposure = Loss $$

- Relying on a couple of key metrics is unreliable: Models have many degrees of freedom and can give the '*right*' answer for the '*wrong*' reasons.
- eg Overstated hazard x understated vulnerability = Correct Loss on an event level or industry AAL
- This can lead to undesirable outcomes: a high hazard event impacting a vulnerable area may have unexpected large actual losses.

Hazard	Vulnerability	Financial Module	Loss Validation
Frequency	Functionality	Post loss amplification	Actual vs Modelled AAL: industry and company
Severity	Loss Cost Relativity vs Claims	Assumptions of zero and total loss	Return period of actual events
Spatial Distribution	Damage Ratio vs Claims	Deductibles	Historical event actual vs modelled loss
	'Unknown' primary modifier performance	Application of complex policy terms	

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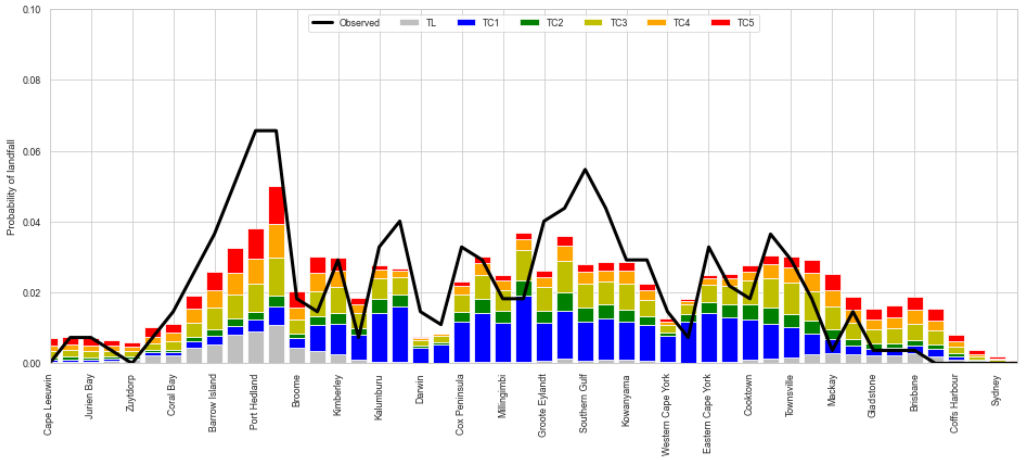
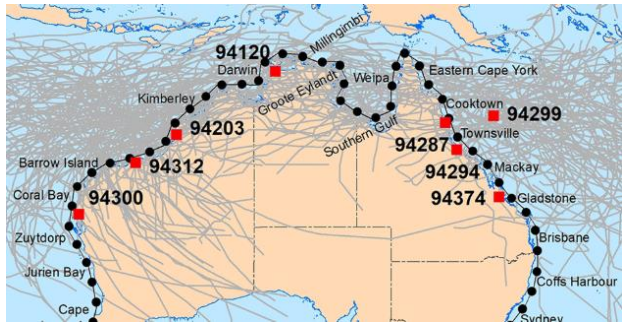
Principle 3: Assess model in components and as a sum of its parts.

Hazard Examples: Frequency and Severity

Frequency: Example Cyclone Landfall

By Gate and Category - TCRM - Geoscience Australia

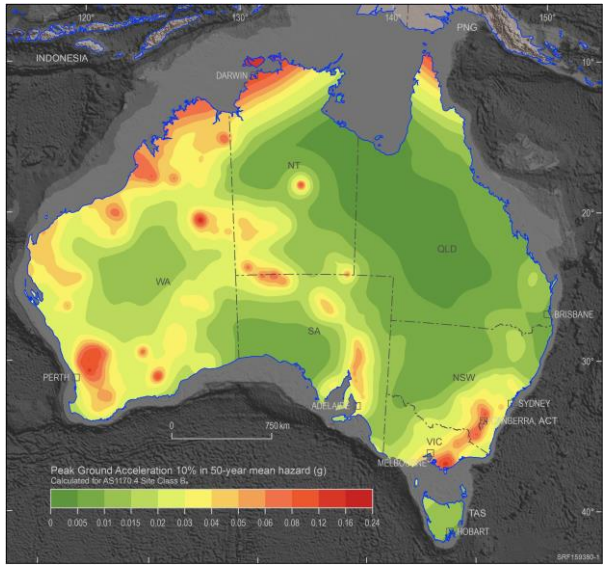


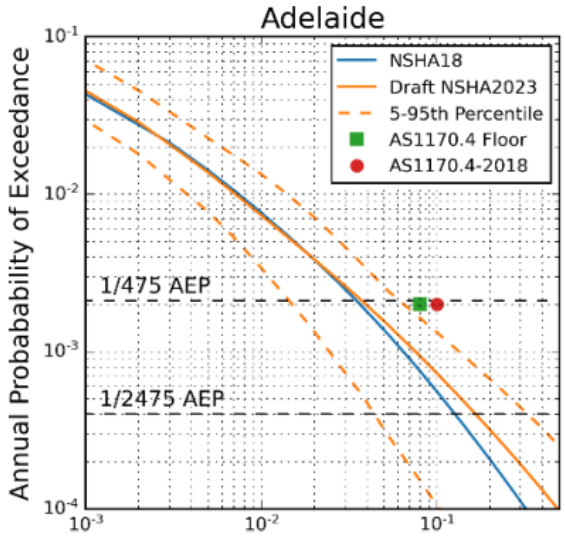


Arthur et al (2021)
https://nhess.copernicus.org/articles/21/893/2021/#&gid=1&pid=1

Severity: Example Earthquake PGA

NSHA23 - Geoscience Australia





https://aees.org.au/wp-content/uploads/2023/11/8.-Jonathan-Griffin.pdf

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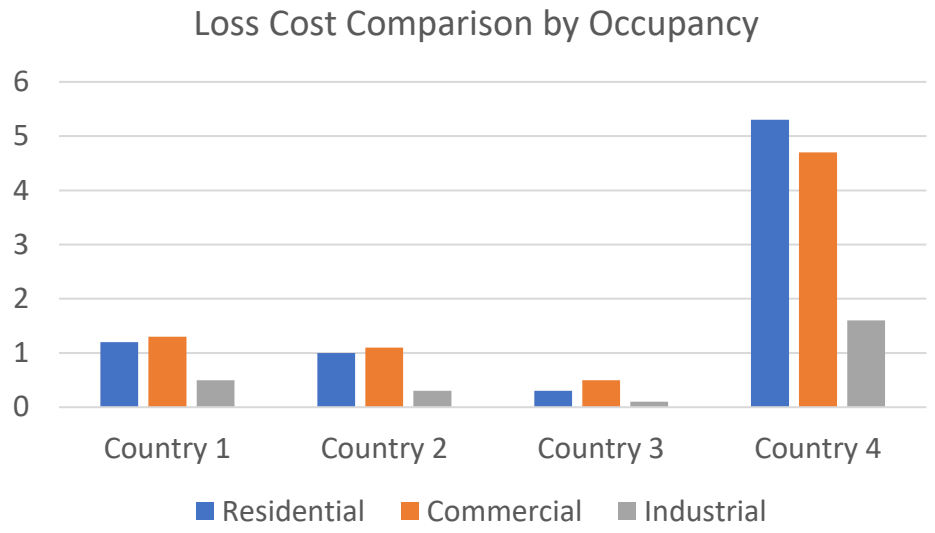
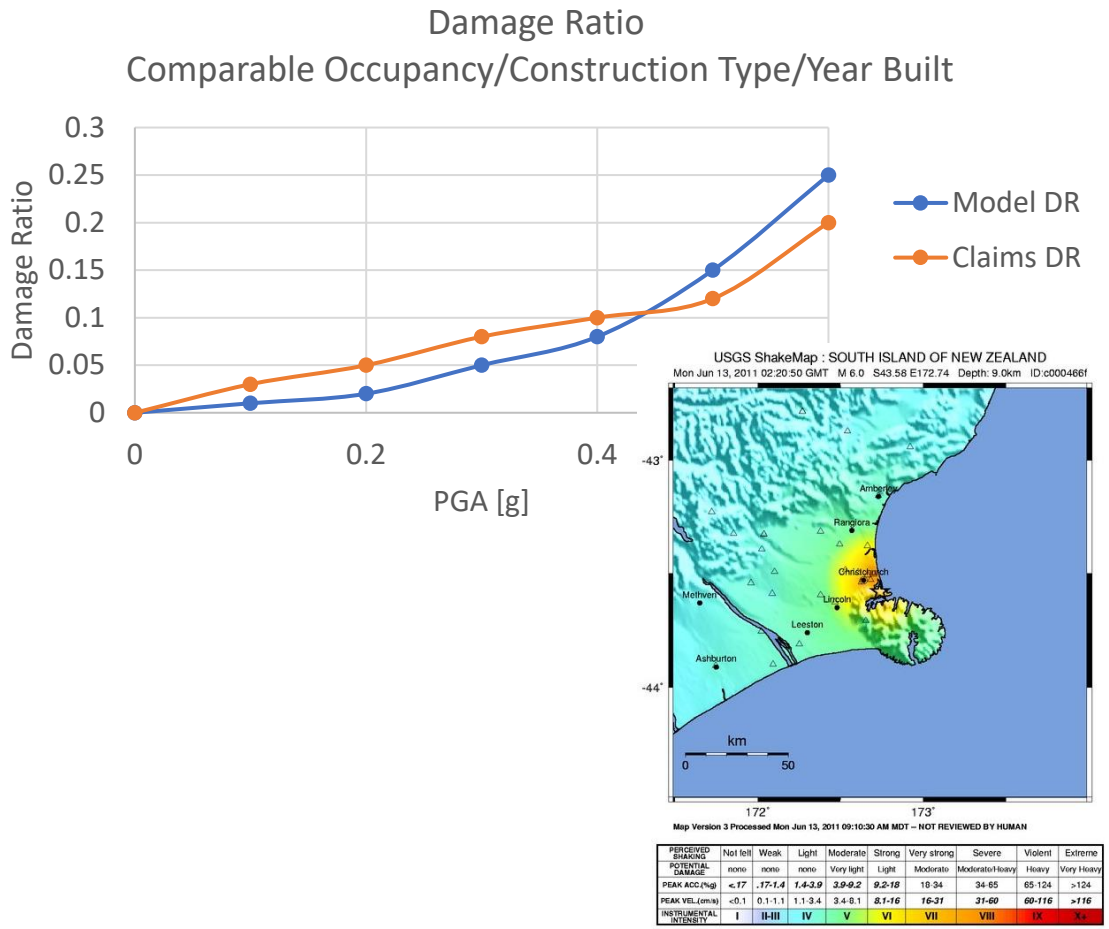
Principle 3: Assess model in components and as a sum of its parts.

Vulnerability Examples: Relativities and absolute damage.

Loss Cost Comparison



Damage Ratio Comparison



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Principle 5: Drill down on aspects of the model that add value.

Identify risk drivers and understand key assumptions.

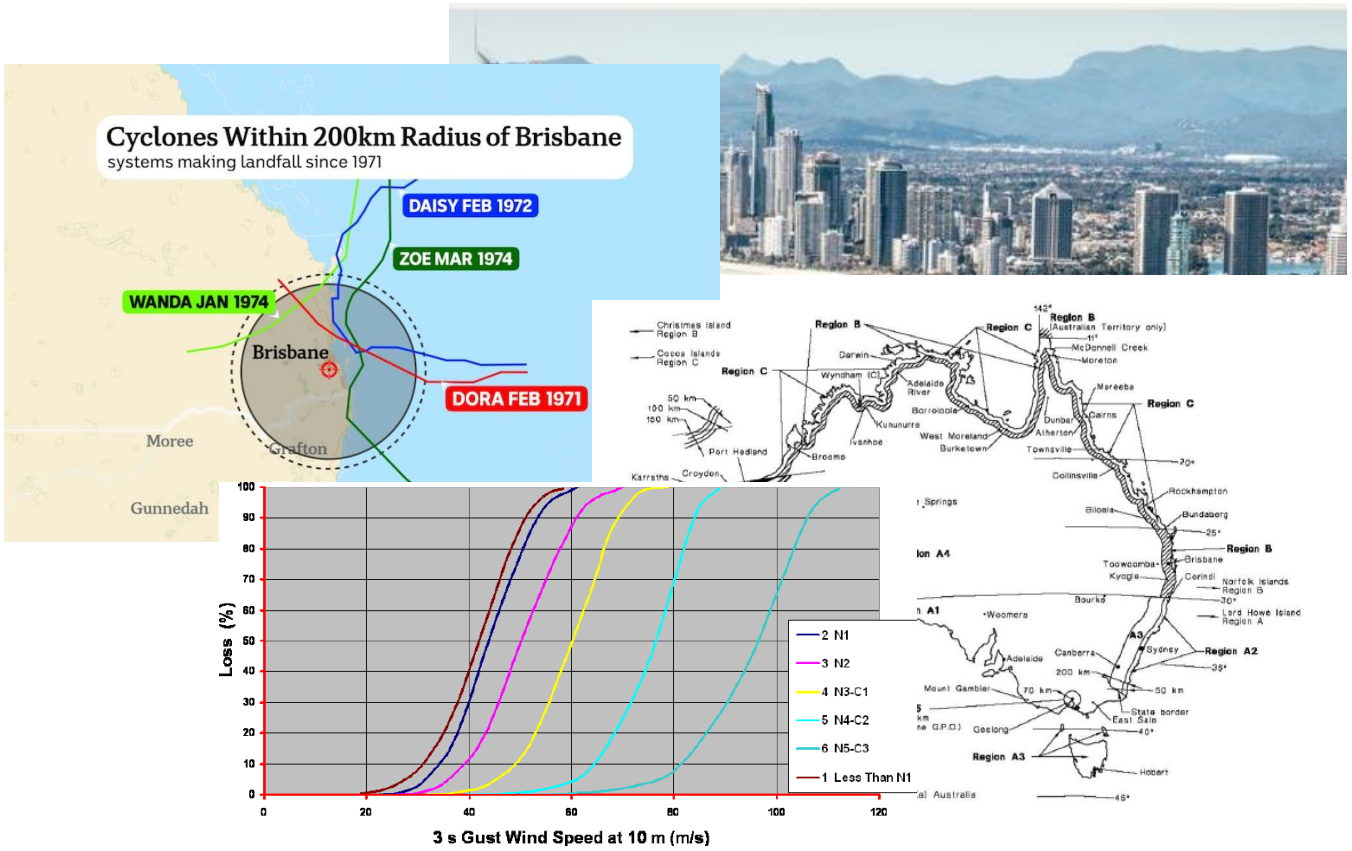
Example: SE Qld Cyclone Hazard – The Perfect Storm

Hazard x Vulnerability x Exposure = Loss $$

- Concentrated growing high value exposure.
- Low frequency and uncertain hazard with unknown trends.
- Wind Region B1 → High vulnerability
- Coincident flood and flash flood losses.

→ **Small changes in modelled hazard lead to large expected loss impacts**

→ **Small improvements in vulnerability would lead to dramatically improved risk profile.**



https://www.researchgate.net/publication/266874962_Housing_damage_in_windstorms_and_mitigation_for_Australia

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Principle 7: Holistically weigh up sources of bias and uncertainty.

A dashboard can help summarise the direction of uncertainties on overall loss.

Identify sources of bias ie components where model may be over or understating risk

- Consider whether there are cascading conservative/non-conservative assumptions

→ *On balance is the model likely over or understated?*

Key
⇧ **Overstatement**
⇔ **Reasonable**
⇩ **Understatement**
! Key Uncertainty
Showstopper

Table: Sample dashboard evaluating sources of bias for a flood model.

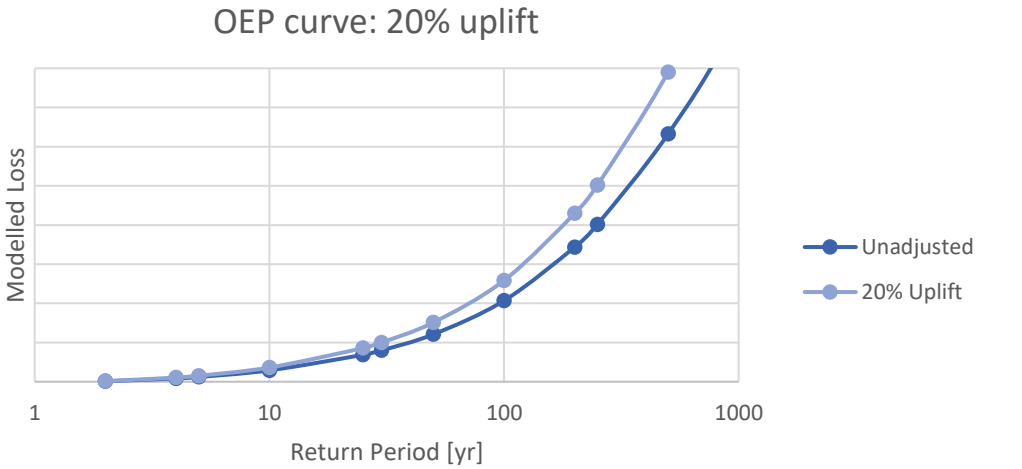
Component	Flood Model A	Assessment	Comparison with Independent View
Hazard	Continuous continent-wide precipitation model is spatially consistent	⇔	XX observed precipitation data.
	Event frequency is reasonable Long duration events **overstated** compared to historical record.	⇔ ⇧	Event frequency compares well with YYY & ZZZ flood databases except for long duration events.
	Flood hazard maps appear generally **overstated**	⇧	Selected local council flood maps
	Model flood defences are up to date	⇔	Latest Environment Agency defence data.
Climate Change	Represent climate as of 2020	⇩	Recent study of short duration rainfall trends
Vulnerability	Loss costs relativities by occupancy, construction type and Year Built are consistent and as expected	⇔	Comparison with granular claims data Comparison with engineering curves
Losses	Modelled losses are realistic in terms of: AAL, Short Return Periods, Historical event losses (no large events have been observed recently)	⇔ !	Comparison with Industry & Company losses
Post Loss Amplification	Impact is consistent with industry range	⇔	Comparison with other models

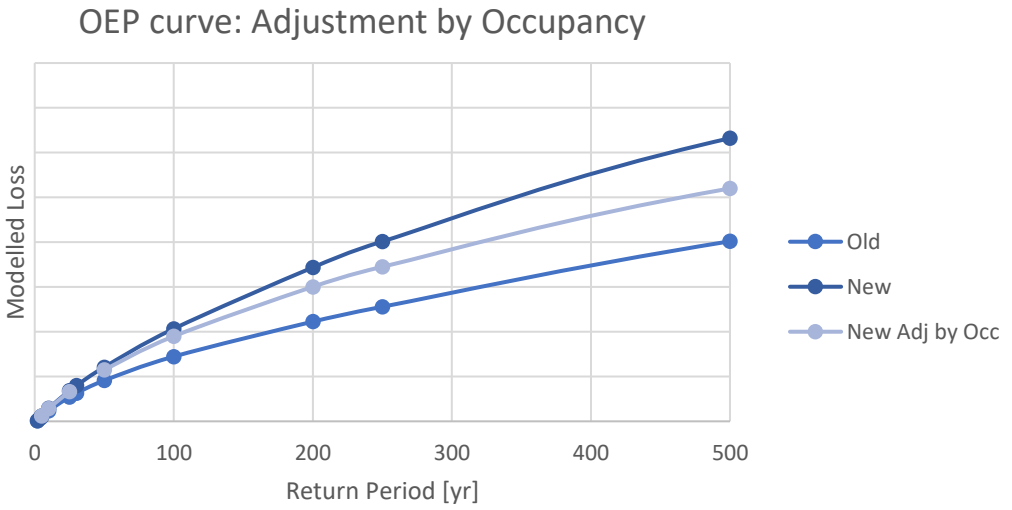
Principle 8: Model limitations can be addressed with adjustments.

Complexity of model adjustments should be appropriate with regard to materiality and justifiable.

Examples of Cat Model Adjustments:

Flat Uplifts	→ Corrects for general mis-statement of hazard frequency, non-modelled subperils, or damage ratio.
By Line of Business	→ Corrects for broad vulnerability mis-statement or company/brand/distribution channel-specific claims pay-out behaviour.
By Primary Modifier	→ Corrects for unexpected behaviour by occupancy or construction type.
Event-based	→ Corrects for unrealistic frequency by severity.





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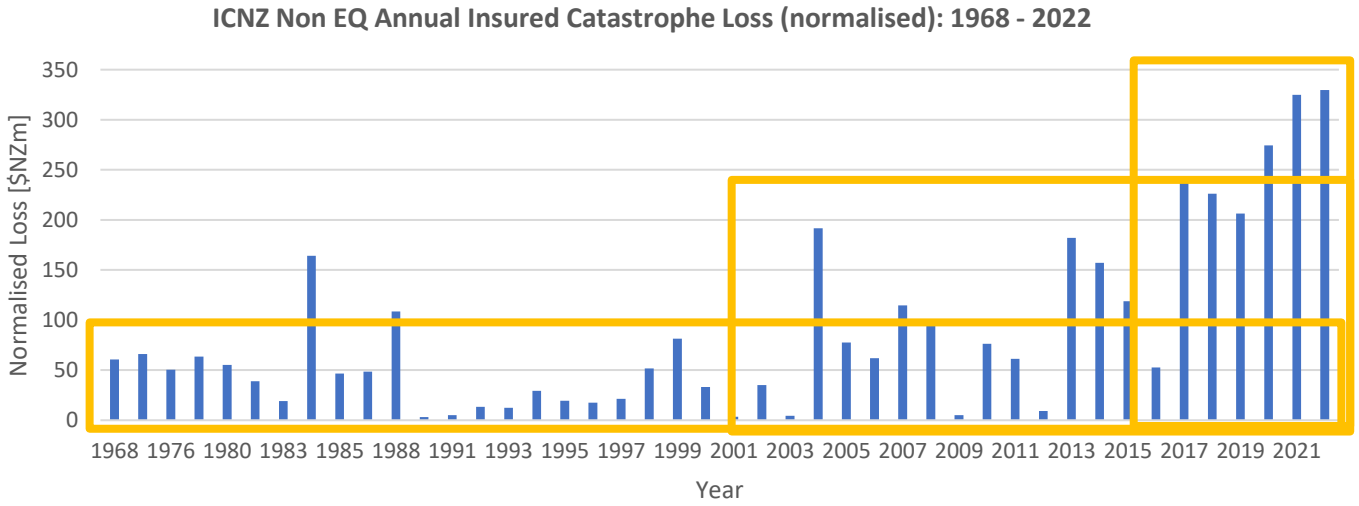
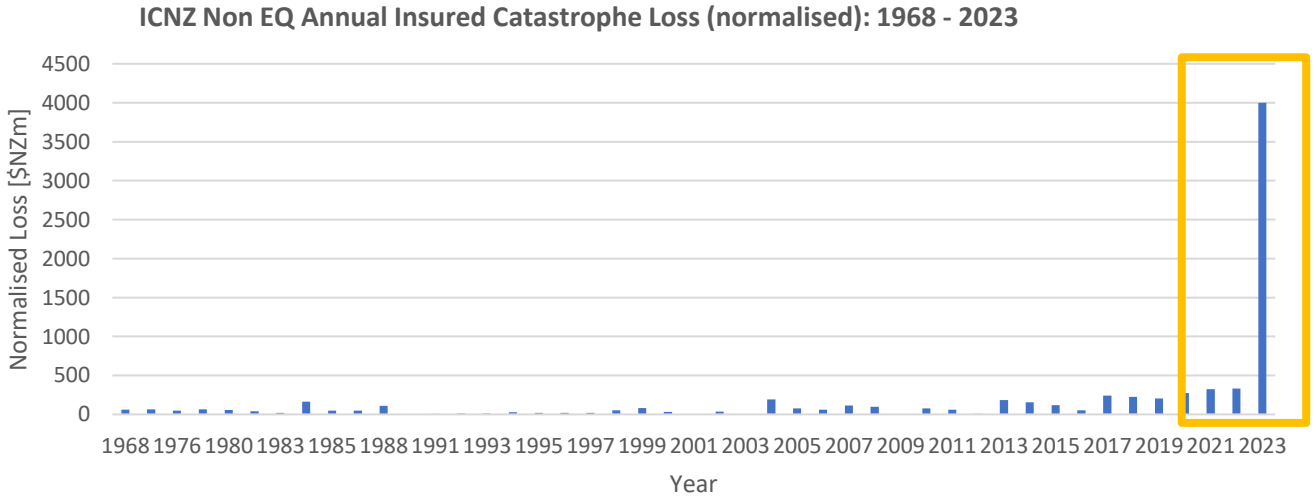
Breakout: Actuals vs Modelled

There are many reasons why Actuals vs Modelled may vary.

- Remember the AAL in the tail
- The recent loss history may be unrepresentative:
  - No significant recent events
  - Outsized recent event
  - Cyclicity
- Granularity: less likely to match actual vs modelled at more granular levels.
- Difference in Data Assumptions: exposure change, inflation etc
- Unaccounted trends in loss history
  - Hazard: climate trends
  - Vulnerability: Building standards
  - Financial: coverage terms, deductibles, underinsurance.





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The Secret Sauce

Model evaluation is a multi-faceted art.

Show Stoppers: Don't rely on check lists - What looks good in parts can sometimes be dysfunctional overall

Multiple Lines of Evidence: Don't obsess over individual data points

Expect More: Transparency from vendors

Don't Fall for Bells and Whistles: A reasonable curve trumps lots of buttons

Avoid the Gold Plating Trap: Work in horizons.

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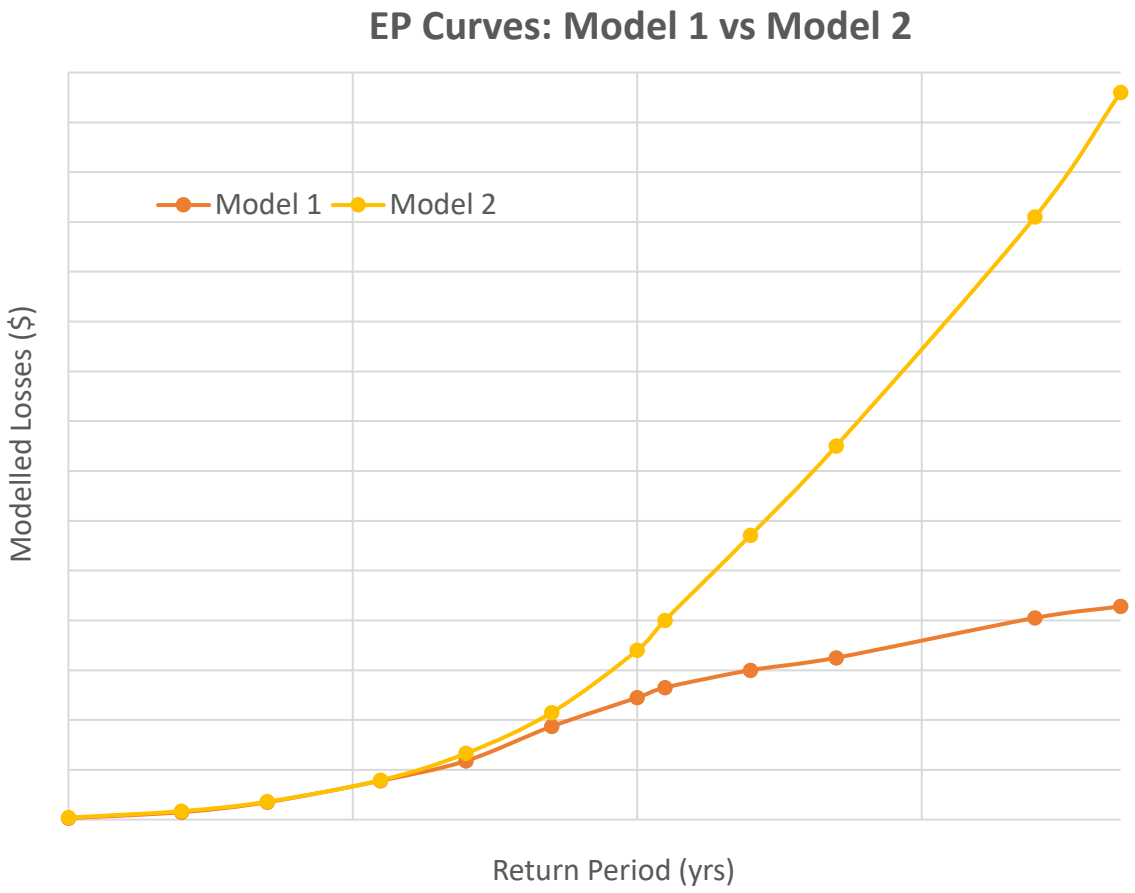
Case Study 1 - Wildfire

Case Study 1 – Divergent Models

- A portfolio targeting newly established communities in outskirts of a major city
- 2 wildfire vendor models were evaluated, and Model 2 was determined to be superior
- **Issue:** Lower RP losses align well, but Model 2 modelled losses has higher increase in the tail
- Further investigation were undertaken to understand why and how to appropriately calibrate the results (if required)



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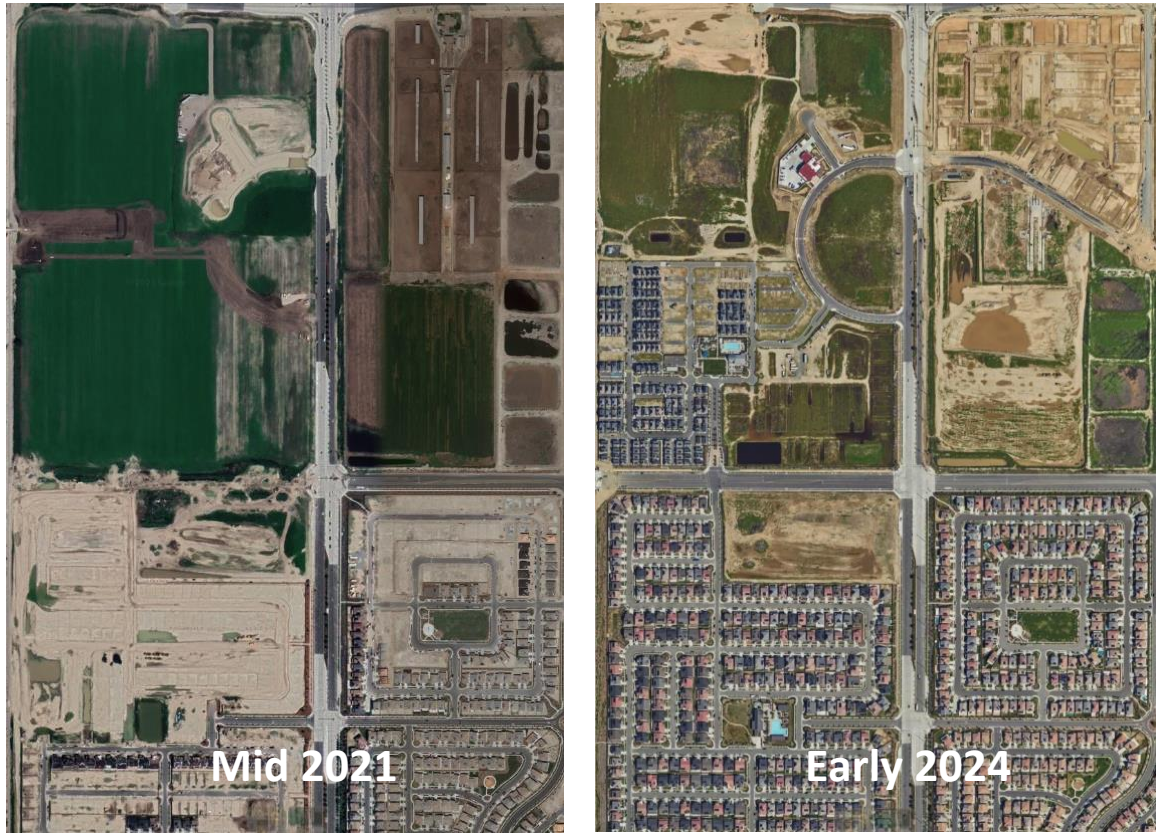
Case Study 1 – Exposure Analysis

- A portfolio targeting newly established communities in outskirts of a major city
  - Land cleared and large number of houses built quickly
  - Subject to stricter building codes, community requirements
- **Hypothesis:** Potential causes for the high tail
  - Exposure concentration
  - Misalignment between vegetation data and actual exposure in new communities



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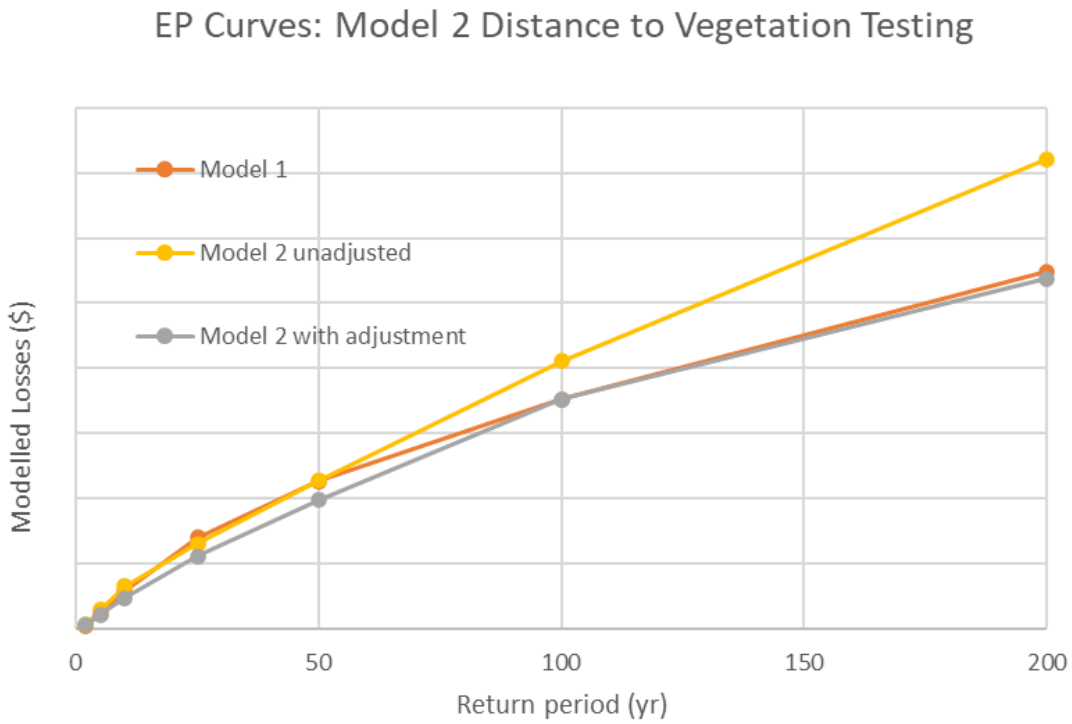
Case Study 1 – Sensitivity Testing

- First approach – take a look at distance to vegetation variable
- One of the key factors in assessing wildfire risk – directly influences how a fire may spread and the level of intensity
- D2V adjusted based on location data
- Lower return period losses and AAL reduced but not the tail
  → requires a further analysis



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Case Study 1 – Tail Analysis

- Closer look at top loss driving tail events
- Every event except for one has most (if not all) of the losses arising from Community A or Community B
- Both are newly built (2022+)
- The hazard module likely not accurately representing the level of vegetation surrounding these communities
- Exacerbated by the concentrated nature of the exposure

Event	Location
1	Community A
2	Community A
3	Community B
4	Community A
5	Community A
6	Community A
7	Community B
8	Community A
9	Community B
10	Western City
11	Community B
12	Community A
13	Community B
14	Community B
15	Community B
16	Community B
17	Community B
18	Community A
19	Community B
20	Community B

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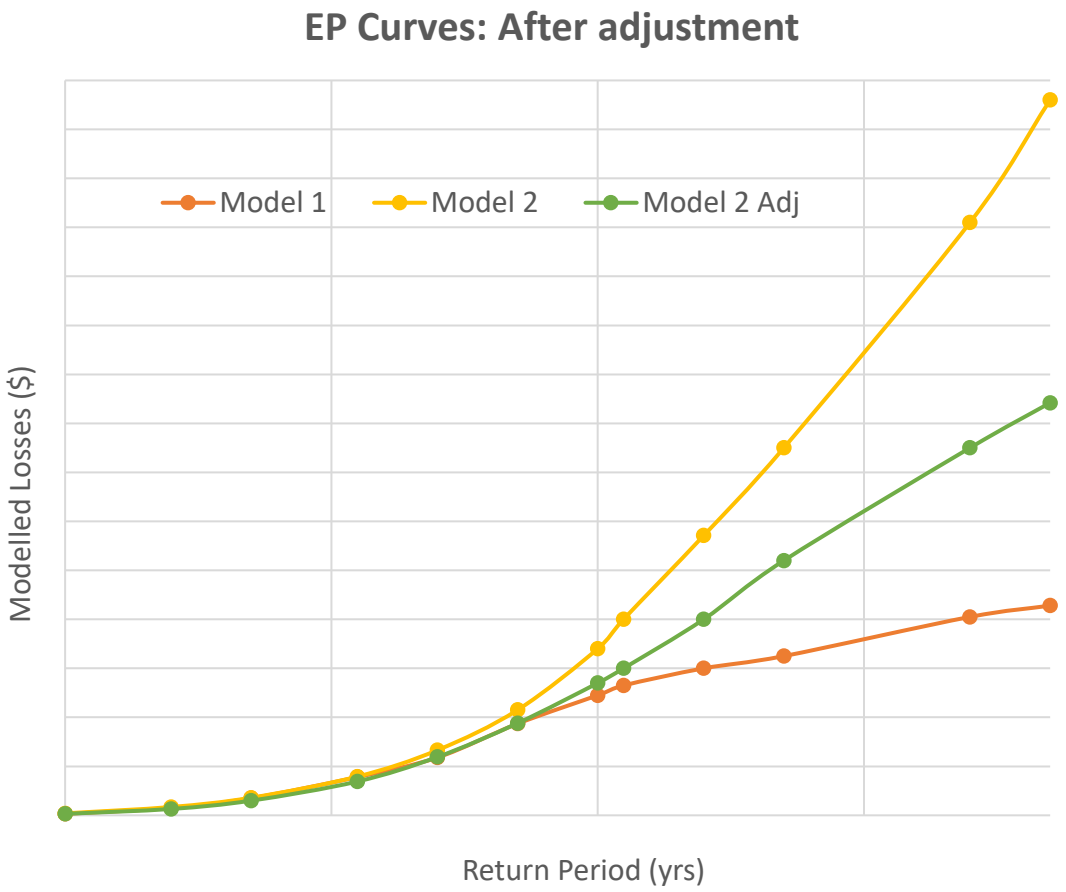
Case Study 1 – Tail Adjustment

- **Solution:** Event level adjustment to correct the over-representation of hazard
- Events with losses above a threshold scaled down by 20-50%
- **Outcome**:
  - Tail losses reduced
  - Minimal impact on AAL as tail contribution was low
- Important to recognise that the higher tail in model 2 is also due to the concentrated nature of the exposures



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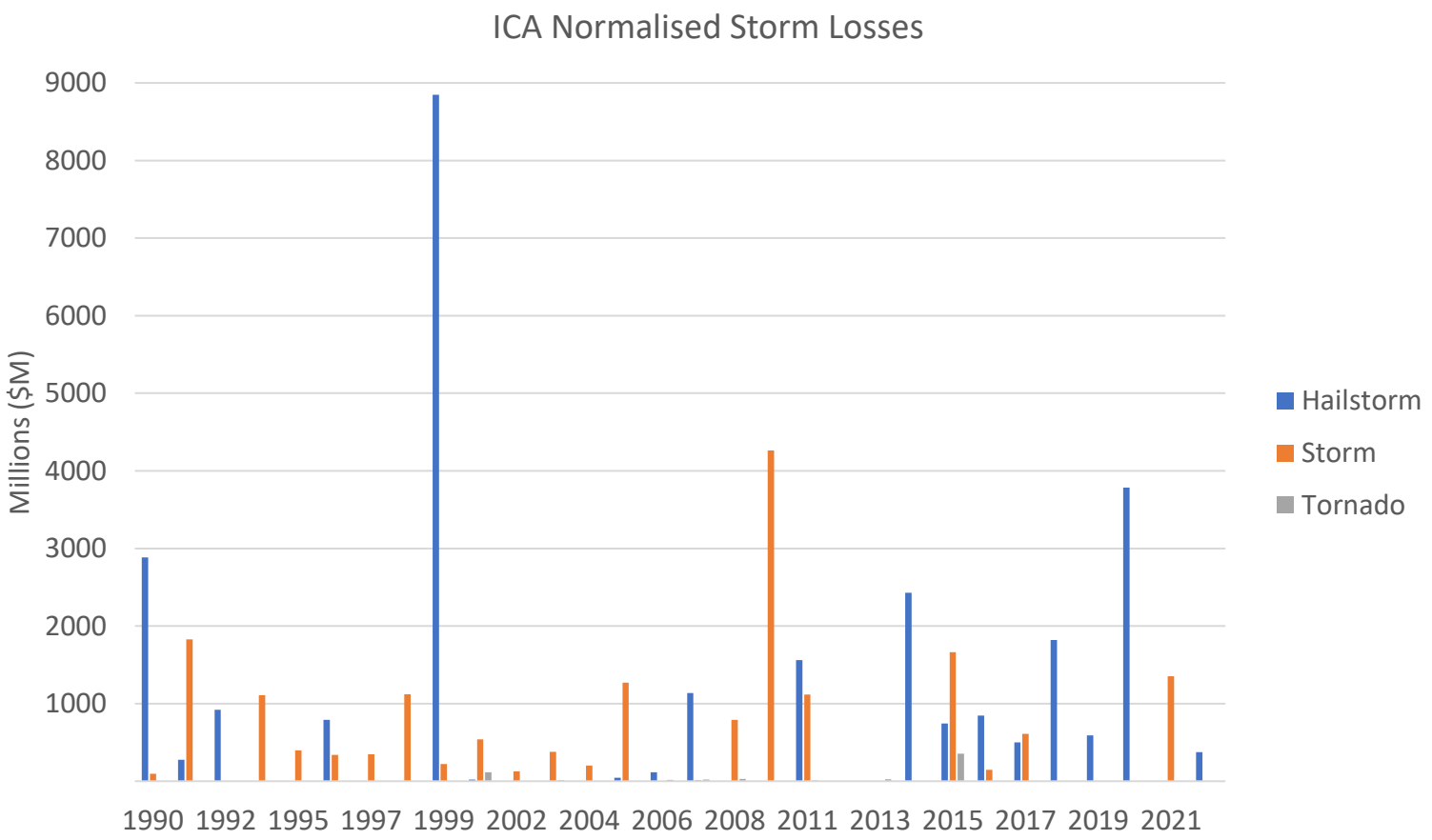
Case Study 2

Case Study 2 – High frequency peril

- Storm and Hail are drivers of catastrophe claims over recent years.
- Should make use of the claims history in evaluating and calibrating the Cat models.
- AAL for the model should align to experience for frequency peril.
- The calibration should be to both by sub-peril and portfolio.
- Alignment including adjustments on the events catalogue, lines of business or primary modifiers.



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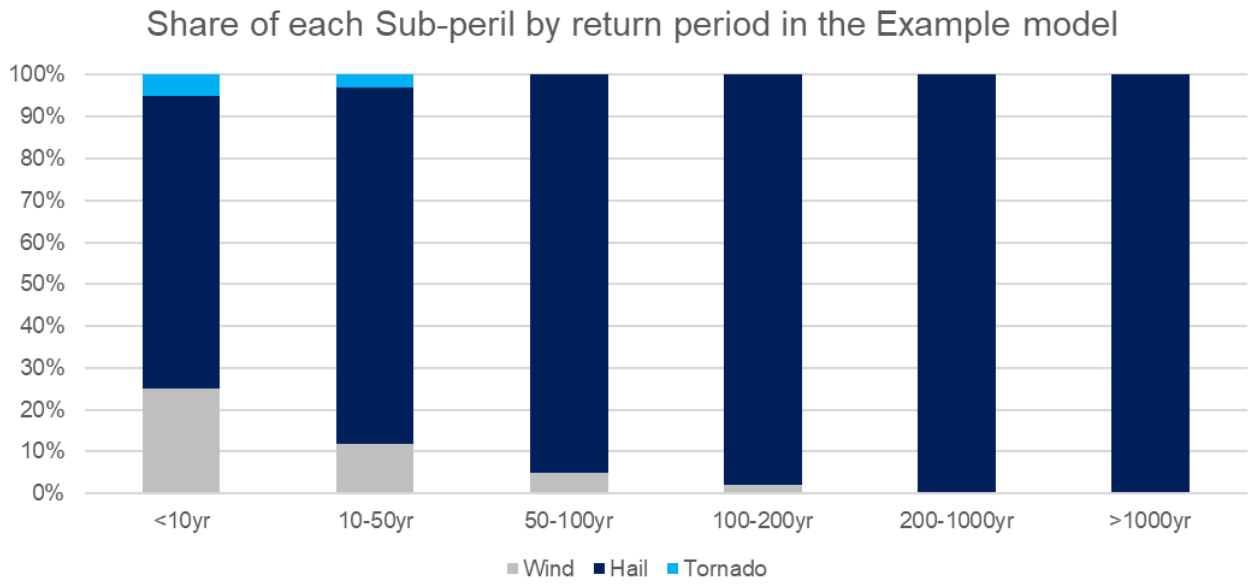
Case Study 2 – Adjustment by losses for sub-peril

- Classification of claims experience by peril/sub-peril is important.
- Most of the events are either classified as hail or storm but in reality, a lot of the events are a combination of both.
- Claims adjustment is required for both exposure change and inflation.
- In the case study model, every event has a certain percentage of loss allocated to each sub-peril.
- Need to compare modelled losses by sub-peril with claims experience; the values maybe unrealistic and would need adjustments.



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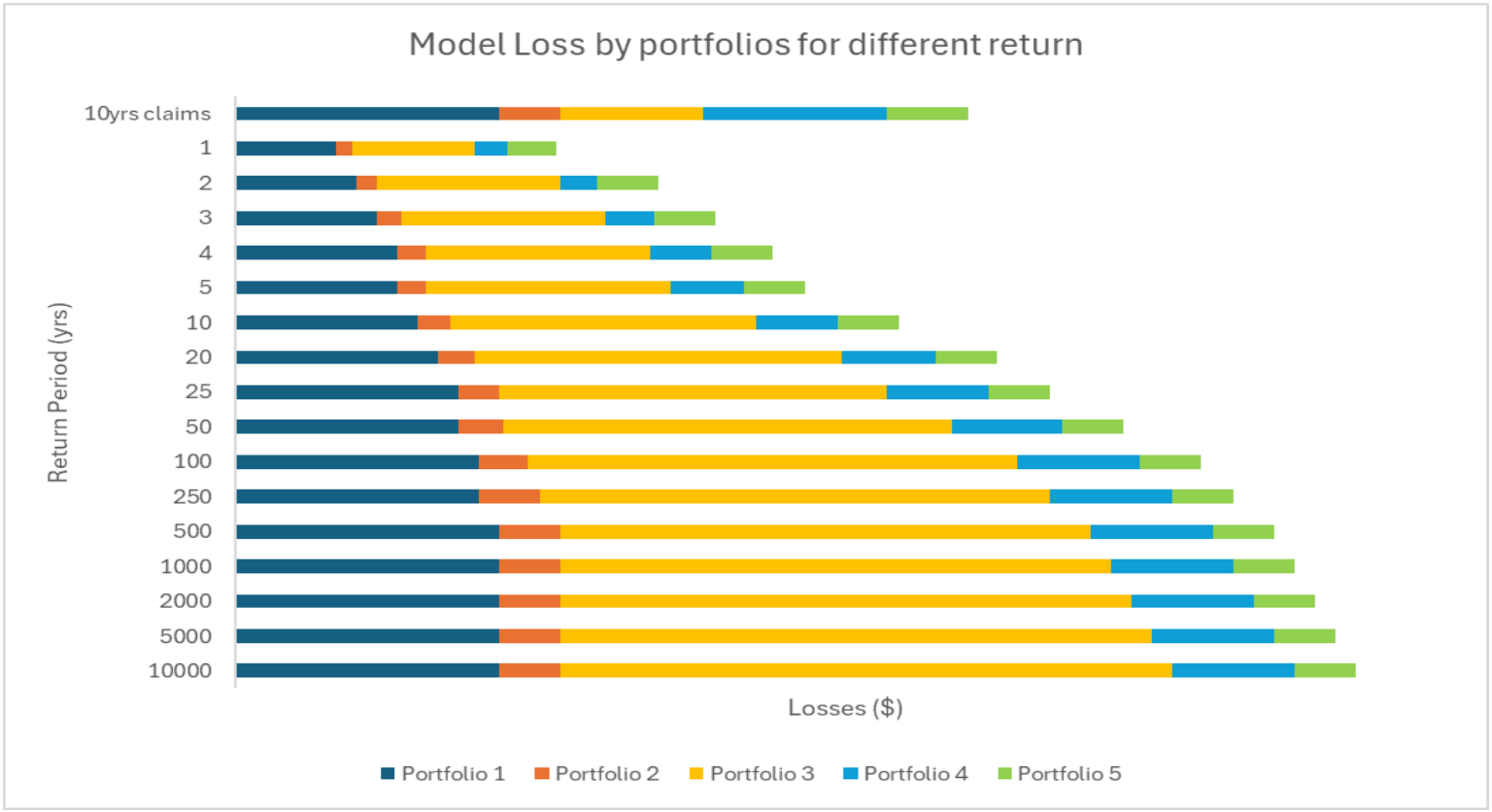
Case Study 2 – Adjustment by Losses for each portfolio



- In the case study model, a large proportion of the Total Loss is coming from small events with lower return periods.
- Portfolio 3 is the main driver of modelled losses across different return periods, even for the small events with high frequency.
- For the 10 years claims history, more losses is from Portfolio 1 and less losses is from Portfolio 3.

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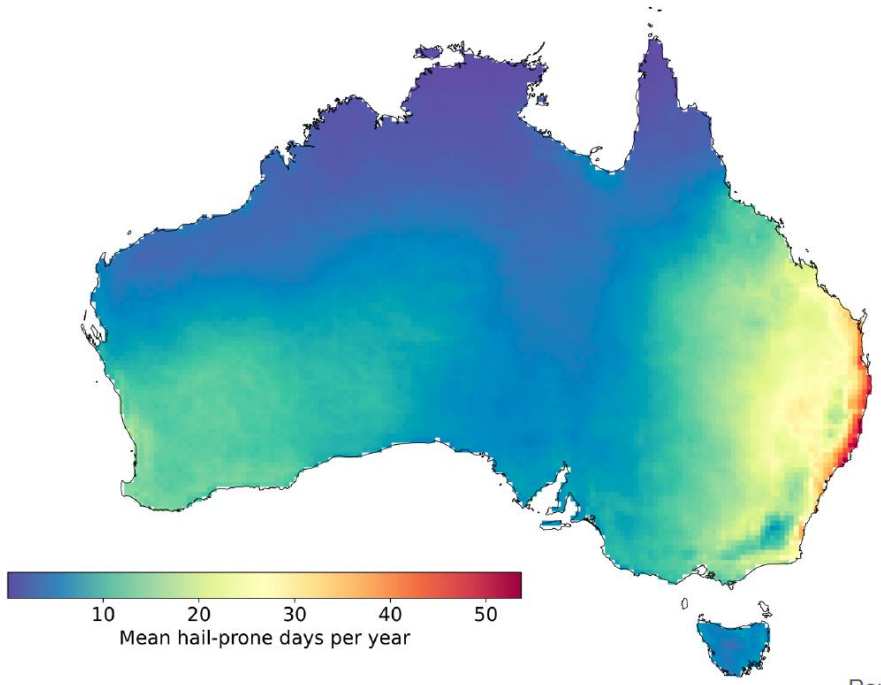
Case Study 2 – Adjustment for Losses by region

- Need to also compare modelled losses by region with experience.
- The values should reflect the science and regional distribution.
- For example, Australia Hail losses are coming from major cities and the East Coast which are more hazardous.
- These regions in the model should also be the drivers for the modelled losses.



Raupach et al., npj CAS, 2023

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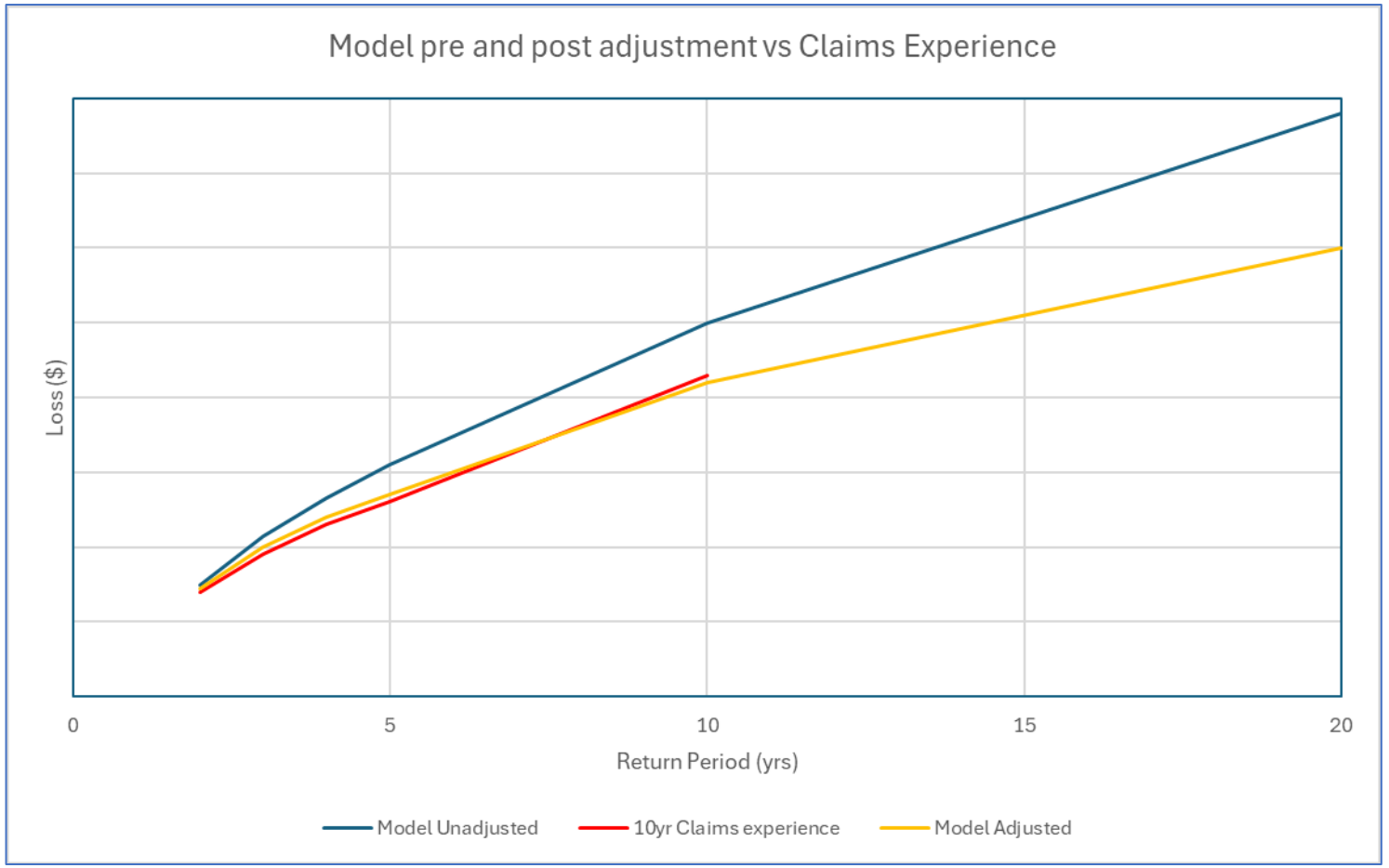
Case Study 2 – Outcome with all adjustments

- Taking the averaging for different period for AAL comparison is considered.
- Need to select period best fit current nature of risk with future climate impacts considered
- Final adjustments adopted for this case study is by both lines of business and events.
- Outcome for the case study model: the low return periods aligns better with the exceedance frequency of the 10 years claims experience.



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Next Generation Models

What's Coming

New features

- Cloud based platforms
- Explicit consideration of duration of events via temporal simulations
- Updated secondary uncertainty loss distributions
- Sensitivity testing functionalities
- Climate change impact built into the models
- Financial modules better equipped to model complex insurance and reinsurance terms

New challenges

- Different output formats and much larger event sets
- IT / operational challenges
- Communicating the difference in results to stakeholders

The Secret Sauce

Model evaluation is a multi-faceted art.

Show Stoppers: Don't rely on check lists - What looks good in parts can sometimes be dysfunctional overall

Multiple Lines of Evidence: Don't obsess over individual data points

Expect More: Transparency from vendors

Don't Fall for Bells and Whistles: A reasonable curve trumps lots of buttons

Avoid the Gold Plating Trap: Work in horizons.

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Q&A

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Feedback

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