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GIRO50 Conference 2023

1–3 November, EICC Edinburgh

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Building Open-Access Tools for Catastrophe Modelling and Parametric Insurance

James McIlwaine
Maximum Information

Introduction

- How do we Model Losses from Natural Catastrophes?
- What is the Risk Explorer and Why was it Built?
- How do we build a Simplistic Catastrophe Model from Historical Data?
- Demo and Future Use-Cases
- Wrap-Up.

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What do we mean by Natural Catastrophes?

Pure Atmospheric

- Tropical Cyclones
- Extra-Tropical Cyclones
- Severe Convective Storms.

Atmospheric/Built-Environment

- Wildfire
- Flood.

Geological

- Earthquakes
- Volcanoes.

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Why do we Model Natural Catastrophes?

- **Natural Catastrophes are costly to insurers and society**

Source: Tom Philp. Fort Myers, Florida post-Hurricane Ian (2022).

- **Natural Catastrophes have certain properties that require special treatment**
  - Potential to generate extremely large losses across accumulations of exposure
  - Driven by physical systems (in combination with human factors) which behave quite differently by peril.

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How do we Model Natural Catastrophes?

Traditional actuarial approaches exist to model losses from natural catastrophes and can be appropriate in certain circumstances. However, the industry standard for the largest portfolios and most material perils however is typically fully-fledged catastrophe models.

1. Frequency/Severity Modelling

Often used in Capital Modelling/Reinsurance Pricing

2. Experience Rating

Can be suitable for some high frequency/low-loss catastrophes

3. Exposure Rating

Including base rates for insurance pricing

Catastrophe Models

Simulated catastrophe events with given physical intensities and locations
interact with exposure and relevant financial terms to produce losses.

Typically produced by specialist vendors/brokers

Loss= f(hazard, exposure, vulnerability)

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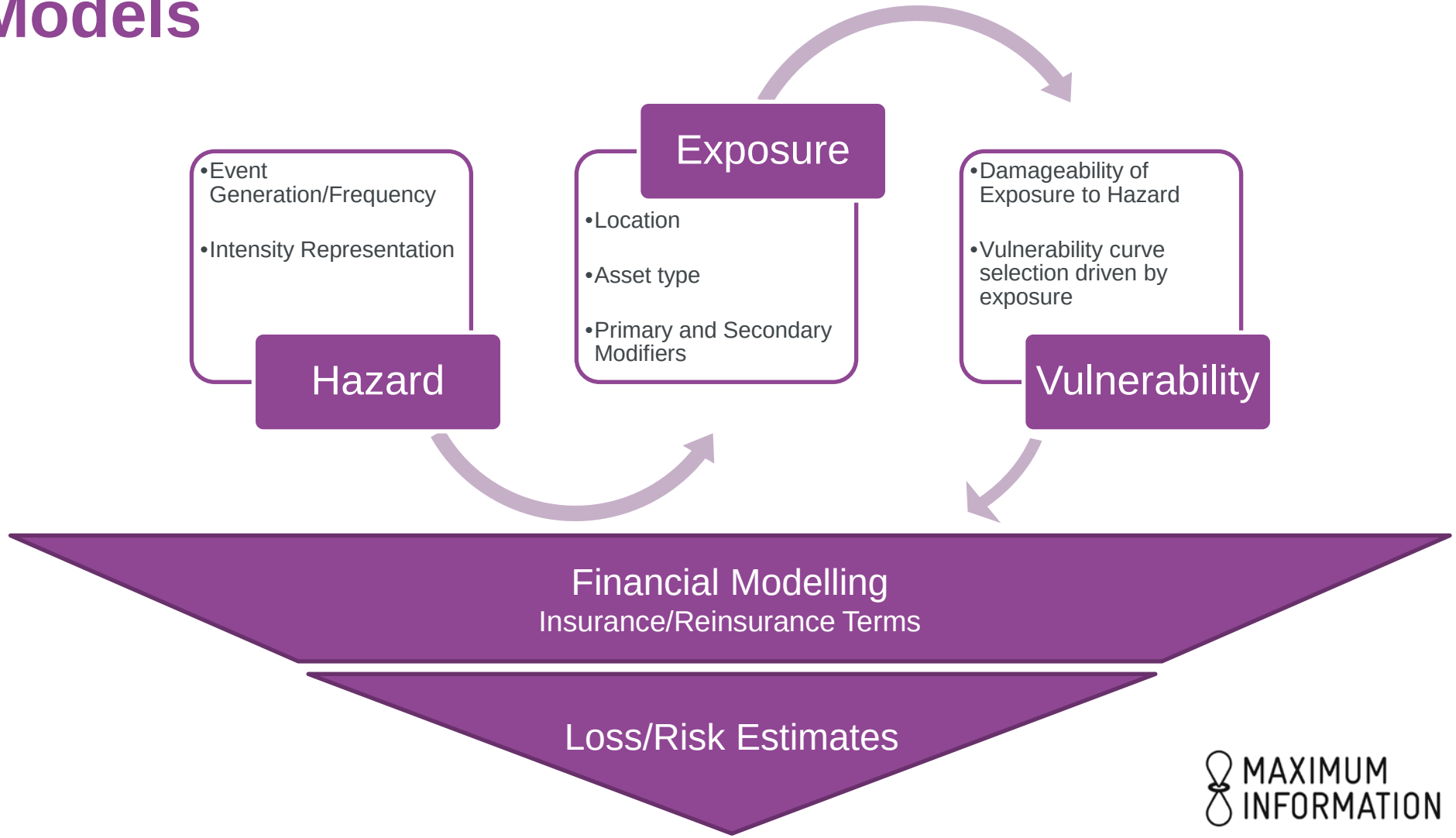
How do we Model Natural Catastrophes: Catastrophe Models



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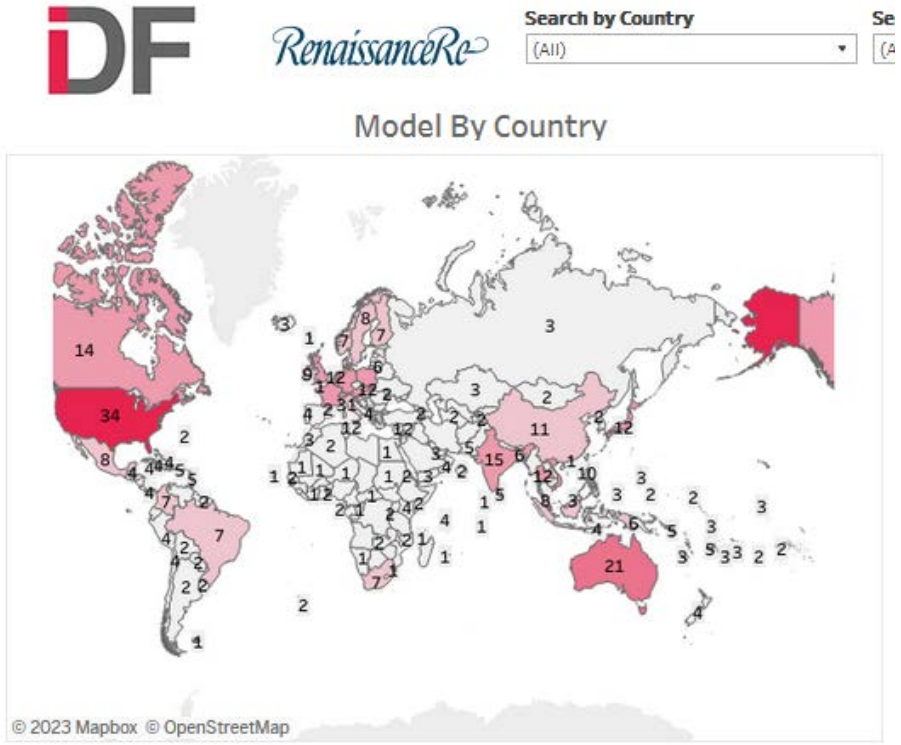
How do we Model Natural Catastrophes: The Need for Not-for-Profit Solutions

- **Cat Models are expensive to produce**
- **Their inner workings can be hard for end-users to understand** due to…
  - Complexity
  - Vendor IP Constraints
- **Lower-Income Countries typically receive less attention from commercial vendors.**



CatRiskTools: a free platform developed by IDF/Renaissance Re that gives an overview of catastrophe model availability worldwide

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Who are the IDF/Oasis and how does the Risk Explorer look to address this need?

Please feel free to submit any questions on the previous section using the link at:

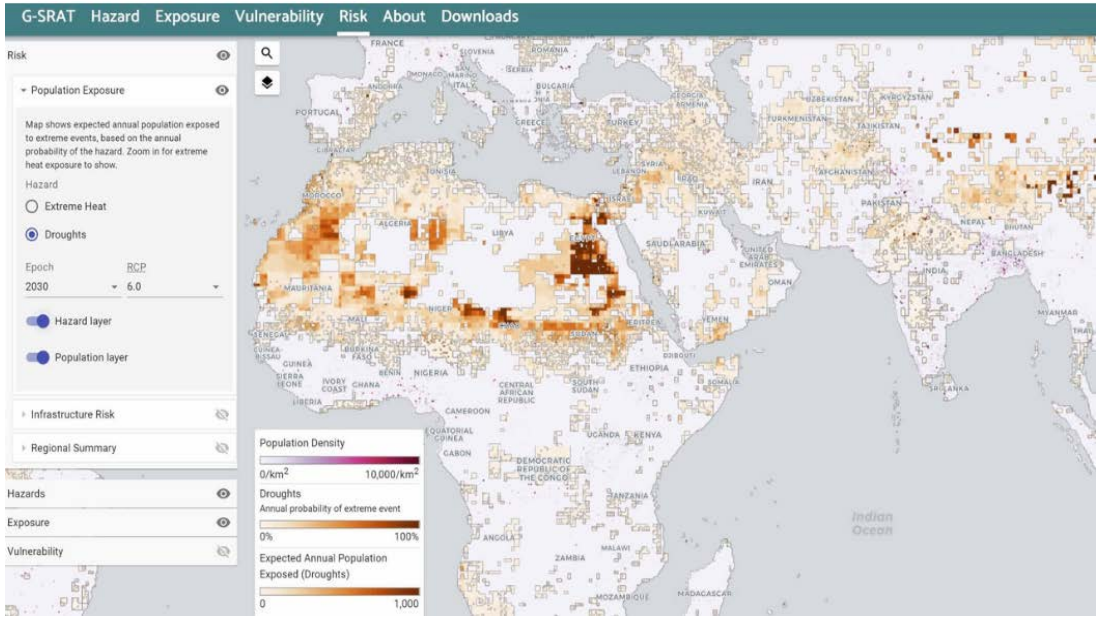
Who are Oasis and the IDF?

Development of the tool was supported by:

Insurance Development Forum: The IDF is a public/private partnership led by the insurance industry and supported by the UN and World Bank.

Oasis: Oasis is a not-for-profit company and community of experts developing open-source software, models and associated tools for catastrophe loss modelling in the insurance industry and beyond.

Who are Oasis and the IDF?



Screenshot from another RMSG project: the GRII (Global Risk Resilience Index Initiative)

- The IDF mission is to optimise and extend the use of insurance and risk management capabilities to build greater resilience and protection for those vulnerable to disasters and economic shocks. **Parametric solutions will be key to achieving this**

- **The Risk Modelling Steering Group (RMSG)** is a working group of the IDF dedicated to improving global understanding and quantification of natural hazards and disaster risk through the use, development and sharing of the re/insurance sector's risk analytics capability.

IDF Insurance Development Forum

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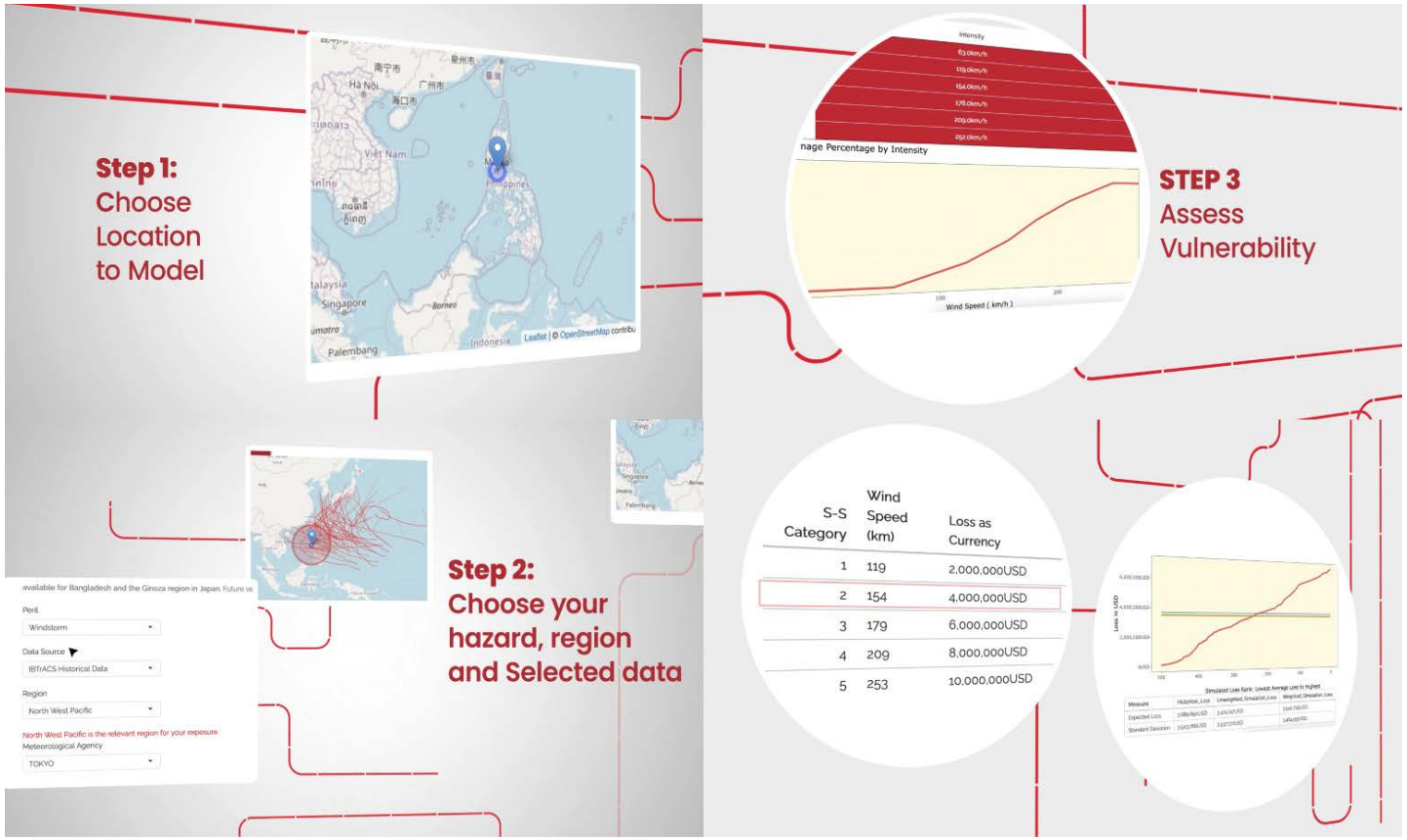
What Is the Oasis/IDF Risk Explorer?

The Risk Explorer is a free and open application built in R Shiny, demonstrating how to estimate losses using hazard, exposure and vulnerability information with a **parametric insurance use-case.**



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But why the focus on parametric insurance and what is it?

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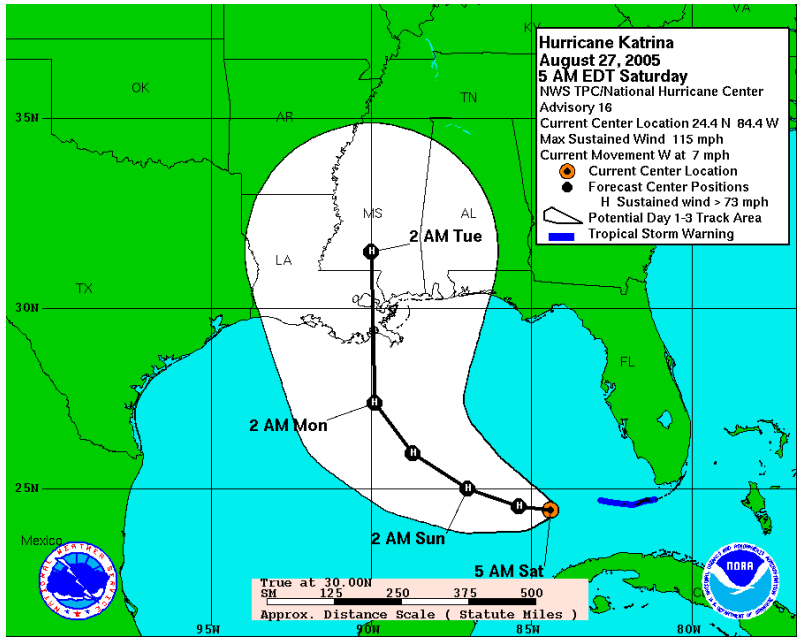
The Parametric Insurance Use Case: Tropical Cyclone Basics

First let's define some tropical cyclone specific terms that will be useful for understanding the subsequent sections…

- **Track:** The path followed by the storm, often represented as a line. Driven by background atmospheric conditions and "beta drift"

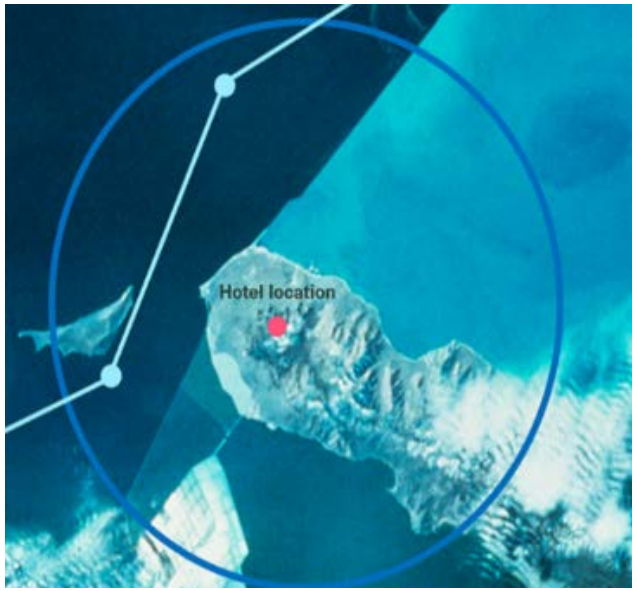
- **RMW (Radius of Maximum Wind):** Distance between the centre of the cyclone and its band of strongest winds.



Source: NHC forecast track for Katrina

Parametric Insurance: What are “Cat-in-a-Box” Covers?

- **Cover is defined by a polygon** (the “box” e.g., the blue circle below) **and a set of payouts** in the case that corresponding physical intensity metrics (the “cat” e.g., wind speed metrics) are exceeded
- When a value of the intensity metric **exceeding the thresholds associated with the cover is observed in the polygon** by a pre-agreed independent source, this **triggers a pre-determined payout to the insured**.
- In the standard framing of a tropical cyclone cover, this would be the **maximum sustained wind speed measured by a meteorological agency along the track.**



BoM Intensity Category	Wind Speed	% of Event Limit	Payout (USD)
1 Tropical Cyclone	63–88 km/h	0%	USD 0
2 Tropical Cyclone	89–117 km/h	0%	USD 0
3 Severe Tropical Cyclone	118–159 km/h	25%	USD 1.25
4 Severe Tropical Cyclone	160–199 km/h	50%	USD 2.5M
5 Severe Tropical Cyclone	> 200 km/h	100%	USD 5.0M

Source: Swiss Re https://corporatesolutions.swissre.com/insights/knowledge/what-is-the-most-popular-parametric-solution-cat-in-a-box-explained.html

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The Parametric Insurance Use Case: “Cat-in-a-Box” covers

- **Cat-in-a-box covers are attractive because they are:**
  - Simple
  - Predictable
  - Transparent
  - Rapid (for pricing and payout)

- However, **basis risk** remains an important factor to consider in cover design (i.e. potential differences arising between loss amount and payout received)

- Note that parametric covers can take many forms, but **cat-in-a-box is one of the most popular.**

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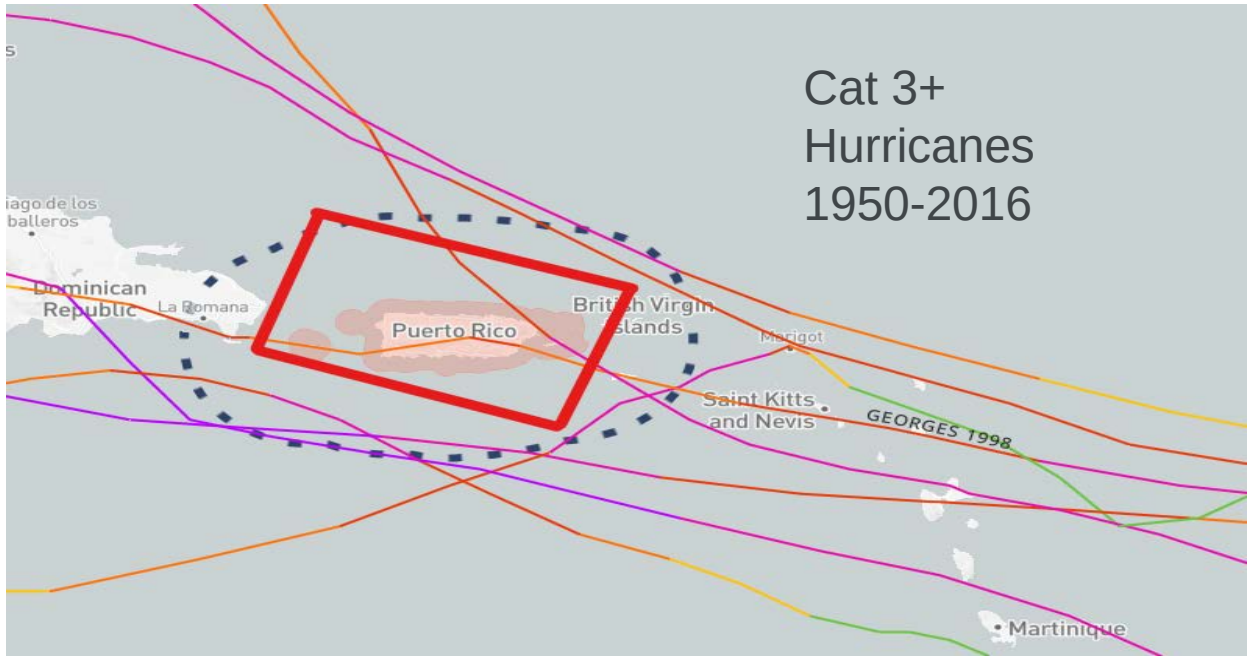
What issues does the Oasis/IDF Risk Explorer aim to address with respect to parametric covers?



Source: Annotated screenshot from NOAA's website : https://coast.noaa.gov/hurricanes/#map=4/32/-80

- **1. Educating users in at-risk countries on the workings of catastrophe modelling and parametric covers.** Poorly designed or understood covers can lead to negative outcomes for the insured and breed distrust in the insurance industry.
- **2. Providing an illustration of the need for an alternative to pure experience pricing.** Notice any potential issues with pure experience pricing for the cat-in-a-box cover displayed?

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With this parametric use-case in mind, what is the basic setup and data/user input to the Risk Explorer?

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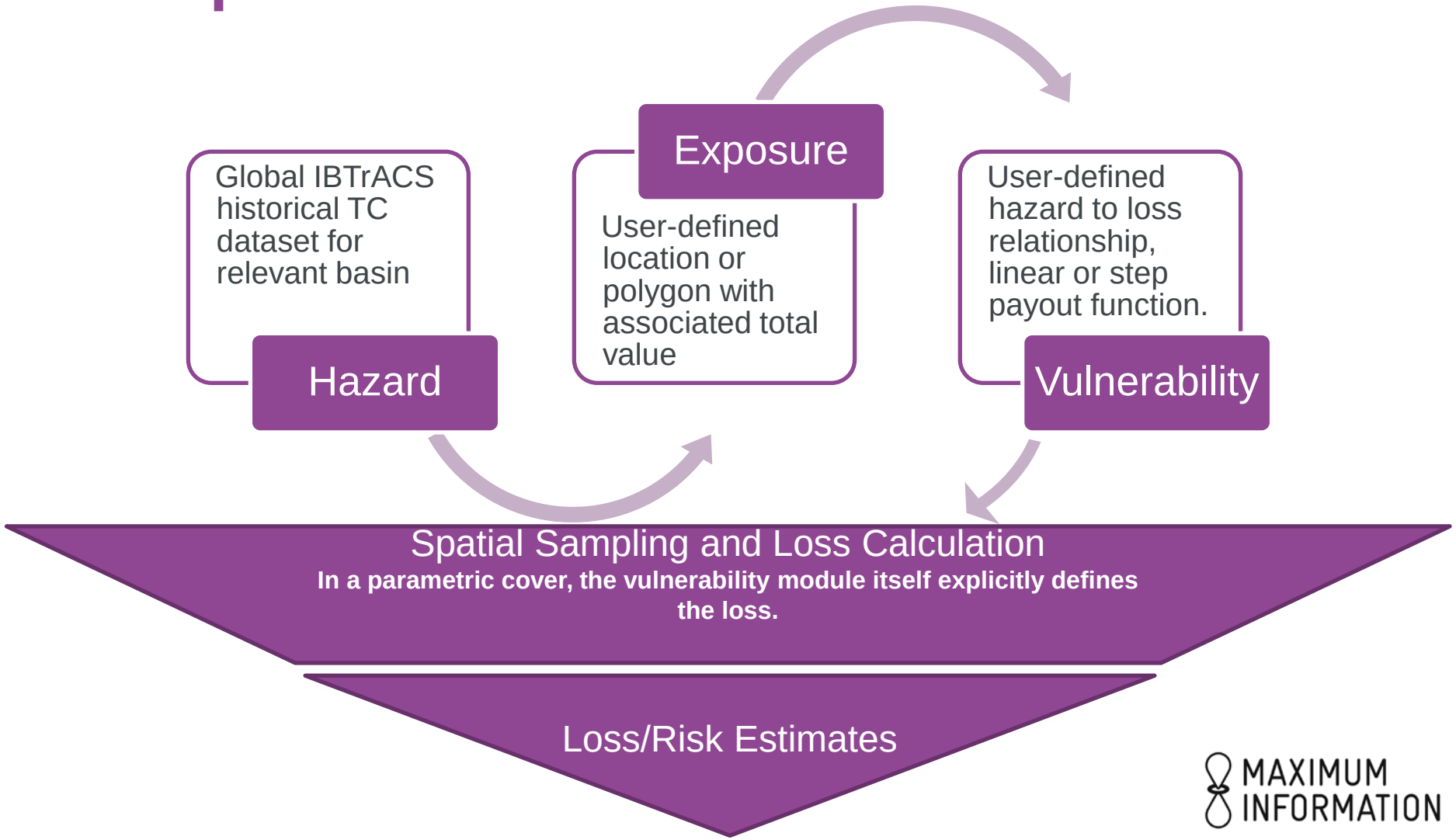
Risk Explorer Structure



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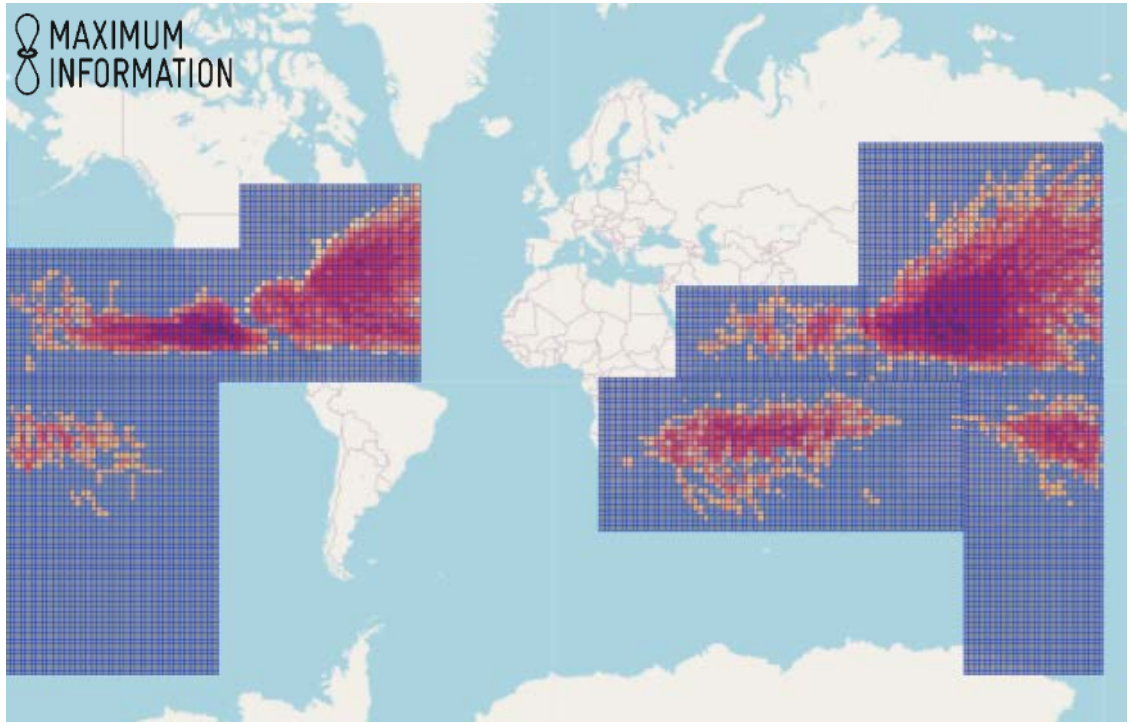
Building a Simplistic Catastrophe Model from Historical Data: Hazard Considerations

The tool ingests two types of hazard data:

- **Historical Data:** Global IBTrACS data which drives the stochastic spatial sampling method. This is a publicly available global dataset containing meteorological readings for tropical storms worldwide. Some factors we need to consider in data cleaning:
  - Which Metrics (e.g., wind speed, pressure etc.)?
  - Which Years?
  - Which Meteorological Agency?
  - Data Adjustments: Timestep Interpolation
- **Stochastic Sets:** Available for selected sub-regions and provided by vendors
  - Tropical Cyclone: Bangladesh (Oasis), Japan – Ginoza (Aon Impact Forecasting)
  - Earthquake: Pakistan – Karachi (Aon Impact Forecasting



Source: MaxInfo - Historical IBTrACS data at 100x 100km grid square resolution

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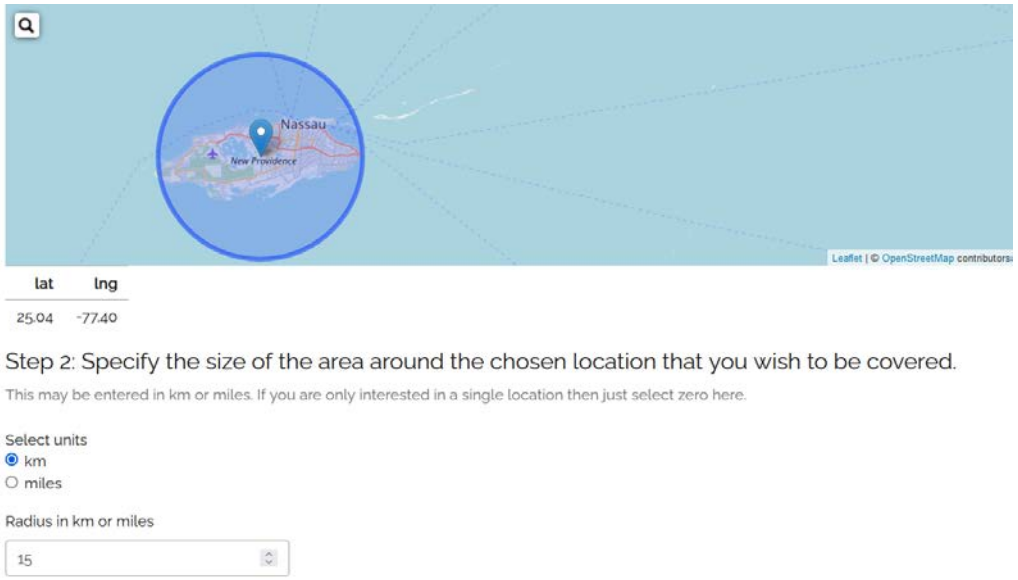
Building a Simplistic Catastrophe Model: Exposure Considerations

- **In a cat-in-a-box cover, the exposure is defined as a geographic area and a maximum payout/value.** The user is restricted to entering circles because:
  - Tropical cyclones are circular
  - Straightforward to specify
  - Fits well with simulation methodology.



- **Minimum radius requirements to ensure adequate protection**

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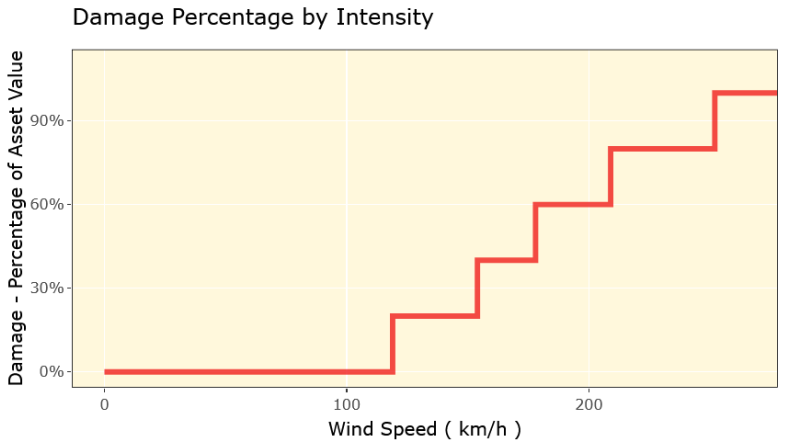
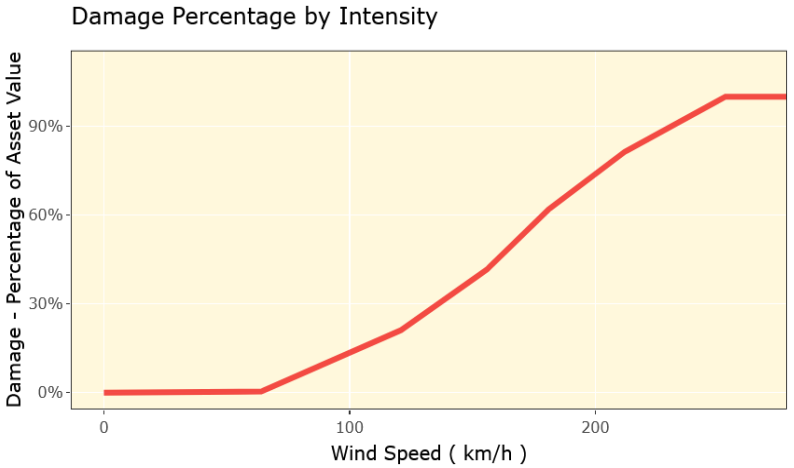
Building a Simplistic Catastrophe Model: Vulnerability

- **Different triggers for tropical cyclone**
  - Wind
  - Pressure
- **Two Types of vulnerability curves (or payout function)**
  - **1. Stepped:** Designed to approximate a parametric cat in a box cover
  - **2. Linear:** Designed to give a crude representation of the type of cat model that would live in a vulnerability function.





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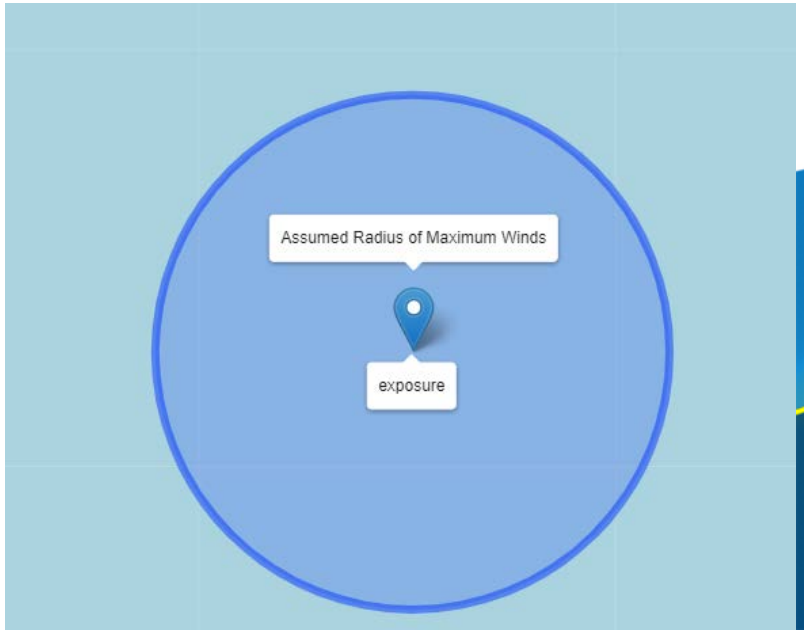
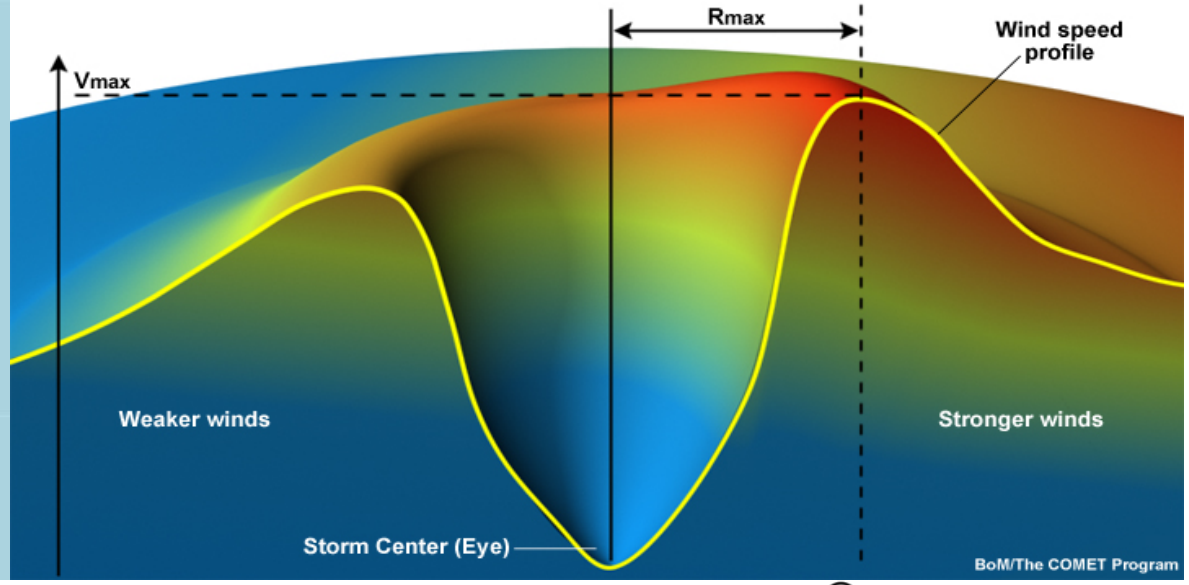
How does the pricing engine and stochastic spatial sampling work?

Please feel free to submit any questions on the previous section at this point using the link at:

Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine

Step 1: Draw a small circle around your exposure equivalent to the radius of your cover. We conceptualise this as an allowance for a "direct strike" from the RMW (Rmax) + your exposure radius. The example assumes a single location – so an exposure radius of zero.





Source: BoM (Australian Government Bureau of Meteorology

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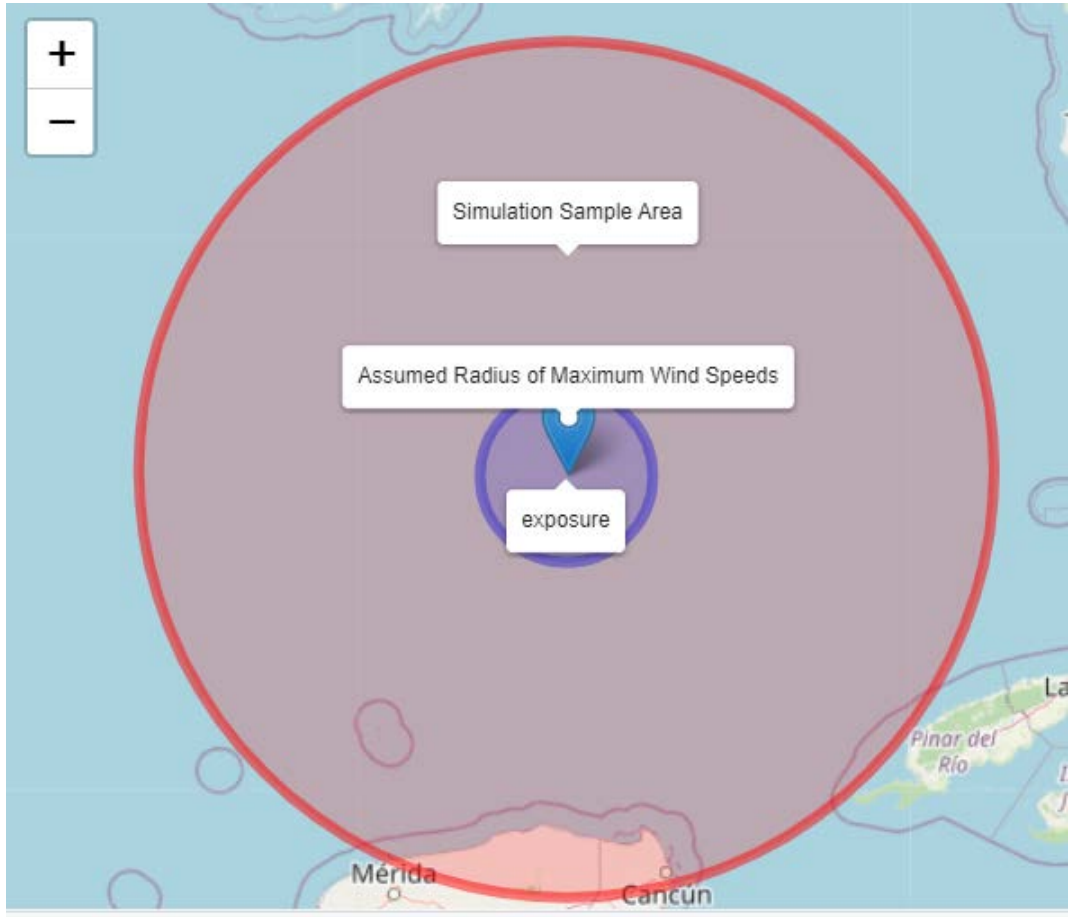
Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine



Step 2: Draw a larger circle around your exposure equivalent to 5 x assumed cover radius. This will be the spatial area to sample from.

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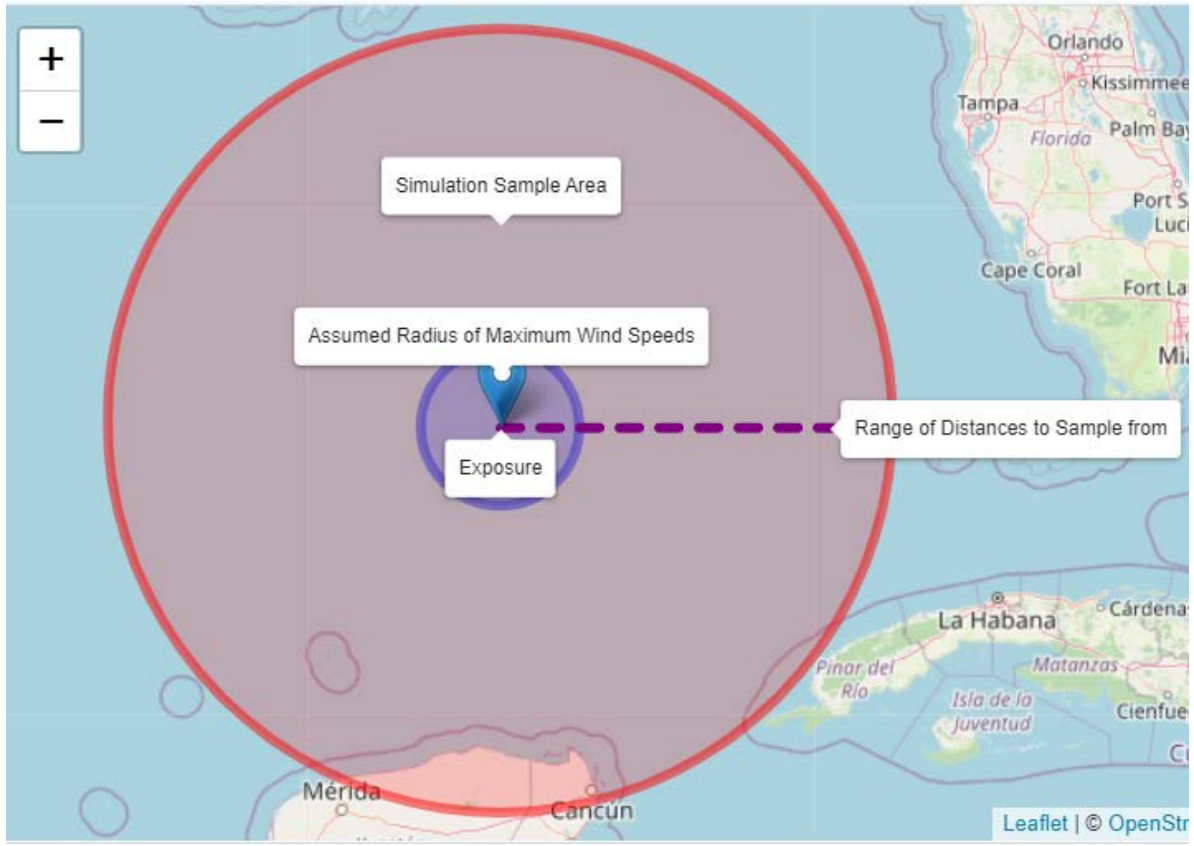
Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine



Step 3: Randomly sample distances from and the exposure from a uniform distribution between zero and the maximum distance to the edge of sampling area.

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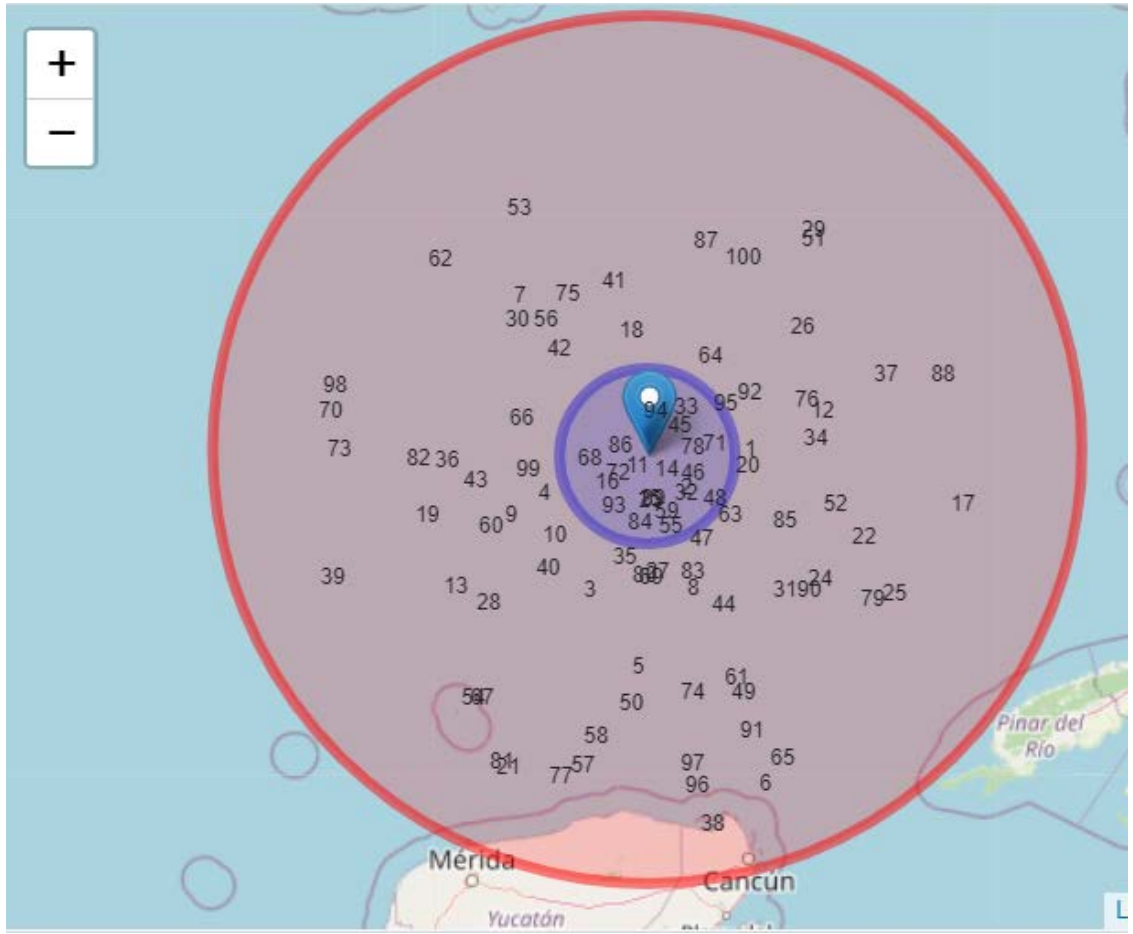
Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine



Step 4: For each distance, also randomly sample an angle from 0 to 360 degrees. This pairing of angle and distance will give you each simulated sampling location.

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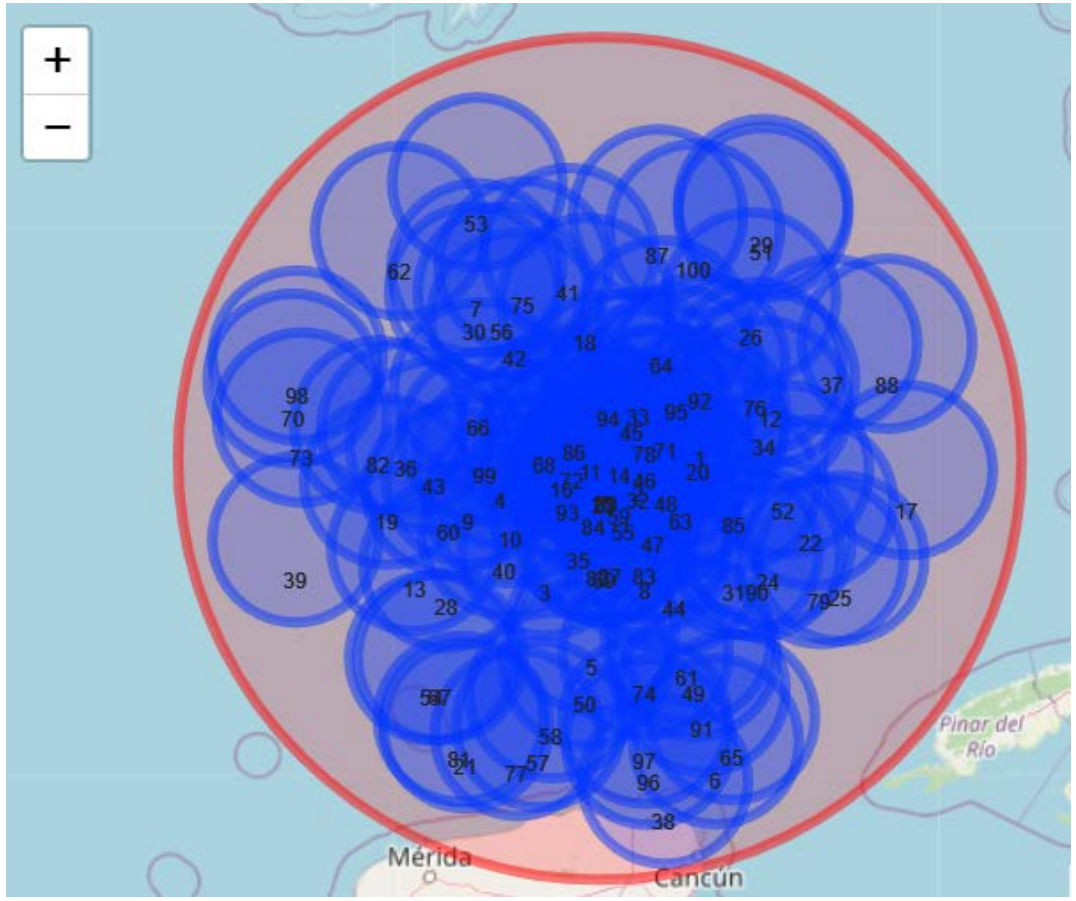
Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine



Step 5: For each location, draw a circle with the cover radius around each simulation point. These will be the individual spatial sample areas to check against the history.

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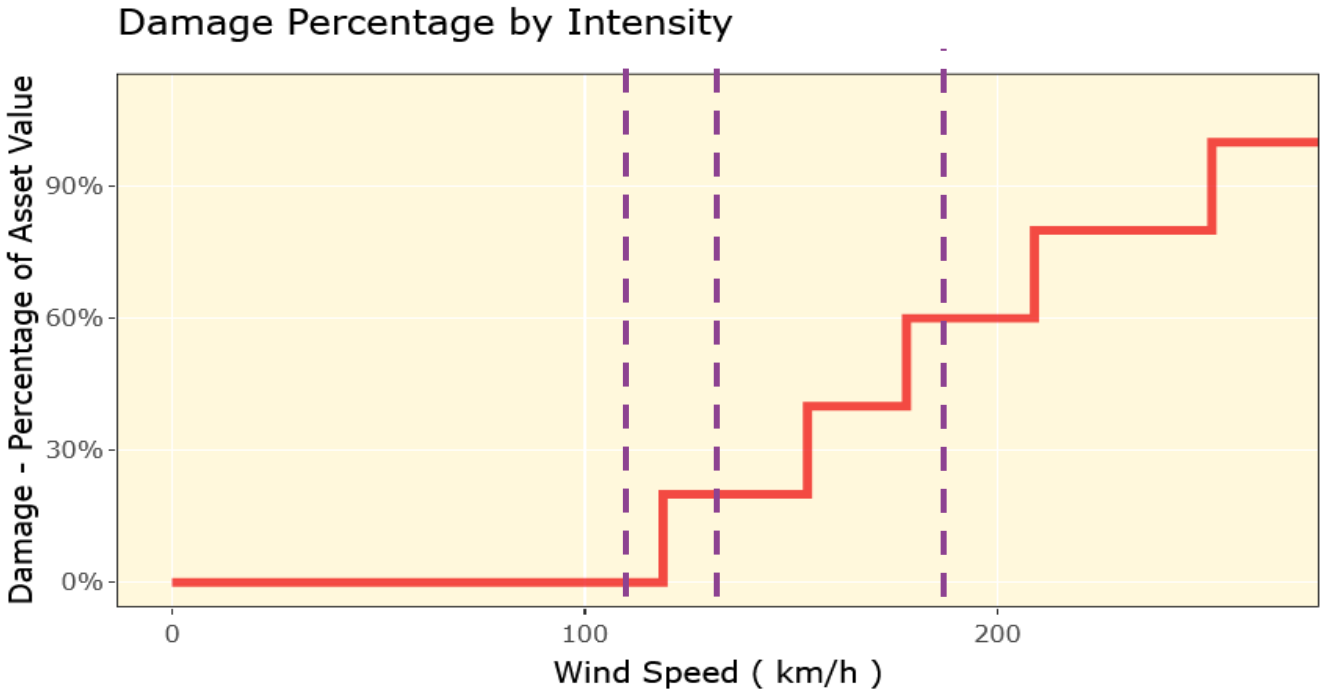
Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine

Step 6: For each of the simulated areas, examine the max wind speeds registered within these for each storm across the history. Overlay the vulnerability/payout function to generate losses for each simulation.



Name	Year	Wind Speed (km/h)	Loss as % of Insured
Storm 1	1981	185	60.0%
Storm 2	2004	110	0.0%
Storm 3	2015	130	20.0%

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Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine

Step 7: Average the annual loss across each year for the simulated area.

Name	Year	Wind Speed (km/h)	Loss as % of Insured
Storm 1	1981	185	60.0%
Storm 2	2004	110	0.0%
Storm 3	2015	130	20.0%
Average (1978-2022)			**1.8%**

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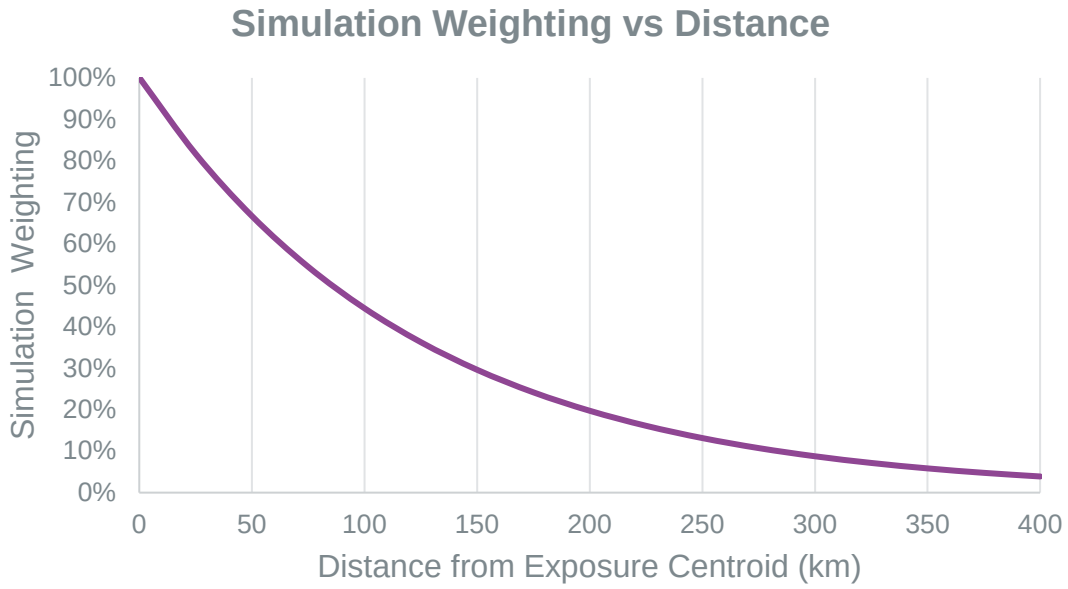
Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine



Step 8: Define a relative weighting for each simulation area given by its distance from the exposure.

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Building a Simplistic Catastrophe Model: Simulation Approach and Financial Engine

Step 9: Average across the simulation averages in step 7 using the relevant weightings for each simulation. This will give you your weighted annual simulation average loss.

Name	Average Historical Loss	Weighting
Location 1	1.8%	45.0%
Location 2	3.4%	35.4%
Location 3	1.0%	9.5%
Unweighted Average	**2.0%**	
Weighted Average	**2.3%**	

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Building a Simplistic Catastrophe Model: Simulation Approach Limitations

- Weighting Function is highly subjective
- Historical hazard data may be of limited relevance in shifting climate
- Assumption of constant RMW by basin and storm
- Inconsistencies in max wind speed measure between meteorological agencies
- Historical data range may not be wide enough to include certain tail events (e.g., Cat 4/5s in relatively low activity basins)
- Circle exposure may not be appropriate for all assets.

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What does the tool actually look like?

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Putting it altogether: Live Demo

- Risk Explorer URL: https://idf-rmsg.shinyapps.io/oasisriskexplorer/

- User Documentation can be found at: https://oasislmf.github.io/RiskExplorer/index.html

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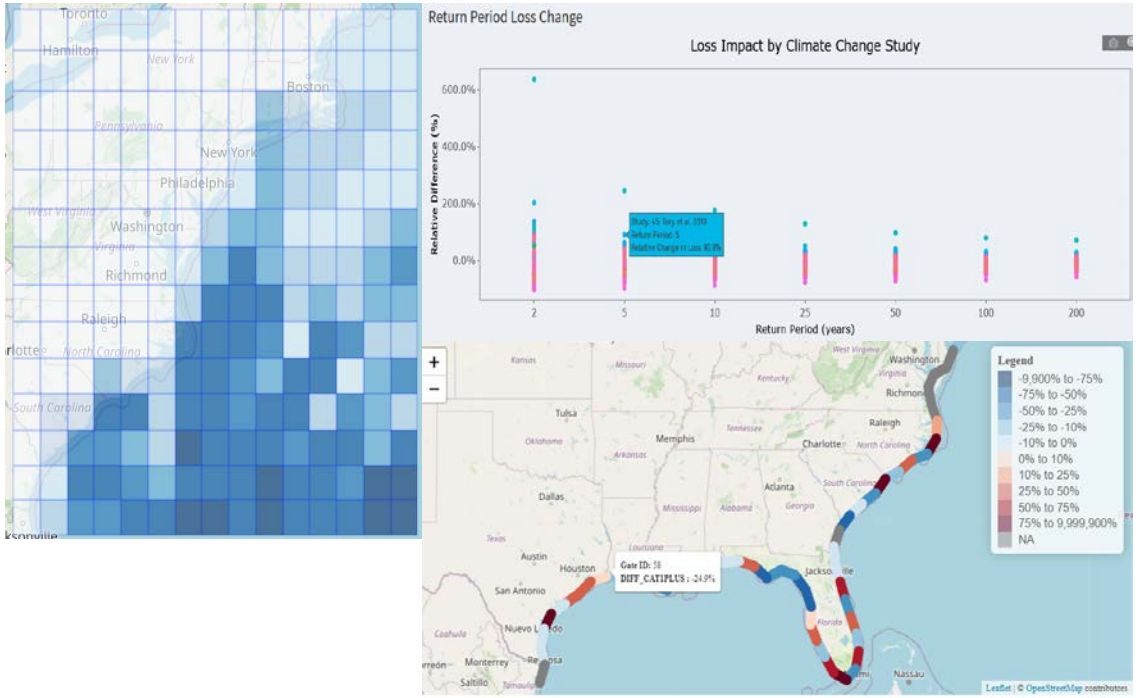
Risk Explorer Development Timeline

Planned to be completed by Q2 2024:

- Inclusion of Weather Indexes (i.e. Drought/Excess Rainfall) in the tool
- Proof of Concept for flood
- Testing and gathering feedback from educational programs across target countries with GRMA
- Scaling IT infrastructure to support larger userbase.

The Inevitable Plug…

- I am the token actuary at Maximum Information, a start-up founded by hurricane scientist Dr. Tom Philp, that aims to equip the re/insurance sector with unique catastrophe modelling analytics & solutions
- We are working with the academic and re/insurance community to provide **SaaS applications that automate and standardize vendor model evaluation and climate change analyses**. Output is independent of – and complementary to – broker analyses
- Steering committee includes:
  - Dr. Kirsten Mitchell-Wallace, Head of Portfolio Management (Lloyd's)
  - Prof. Ralf Toumi, Department of Natural Sciences and Grantham Institute for Climate Change (Imperial College London)
  - Dr. Richard Dixon , Head of Catastrophe Research (Inigo)
  - James Havard, Head of Exposure Management (Convex).



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Questions

Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

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Thank you