Society of Actuaries in Ireland

Understanding Cat Modelling
Inputs, outputs and the future

Wednesday – 14th March, 2018

Agenda

Time	Title	Speakers
6:30pm – 6:35pm	Welcome	Cecilia Cheuk
6:35pm – 6:45pm	Know your storms	Chris Werner
6:45pm – 7:35pm	Understanding Cat Modelling	Paul Jones
7:35pm – 7:50pm	Questions & Answers	Chris Werner / Paul Jones
7:50pm – 7:55pm	Closing	Cecilia Cheuk

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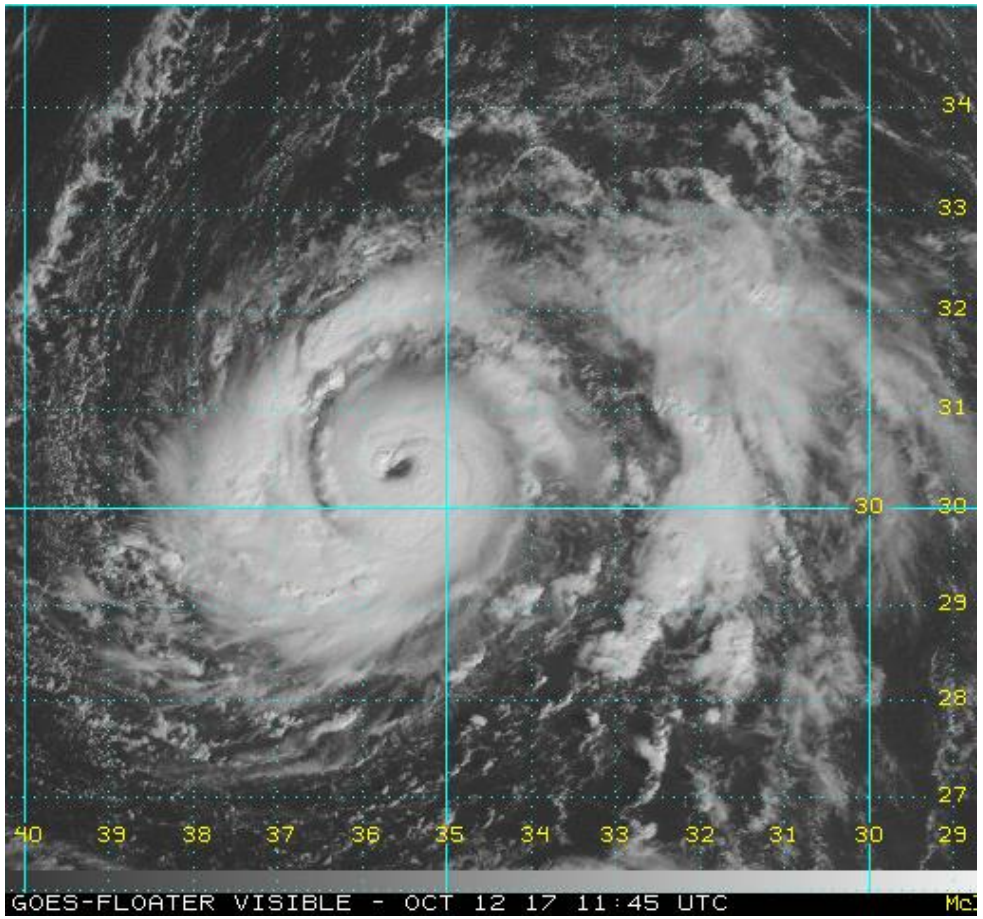
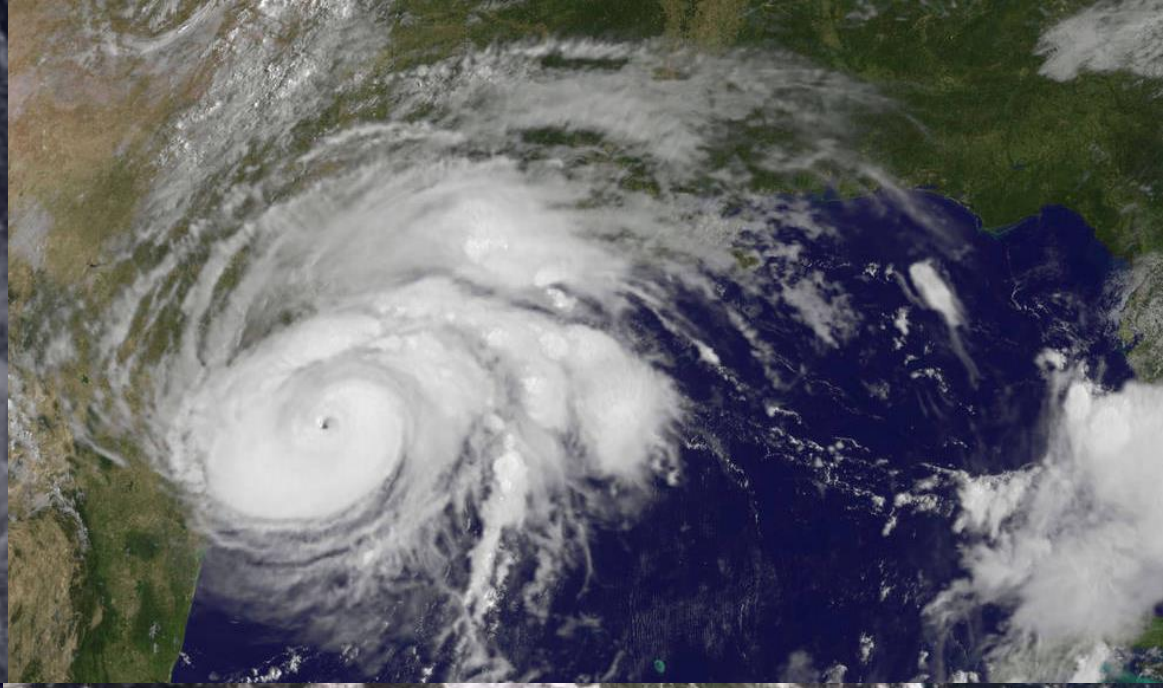
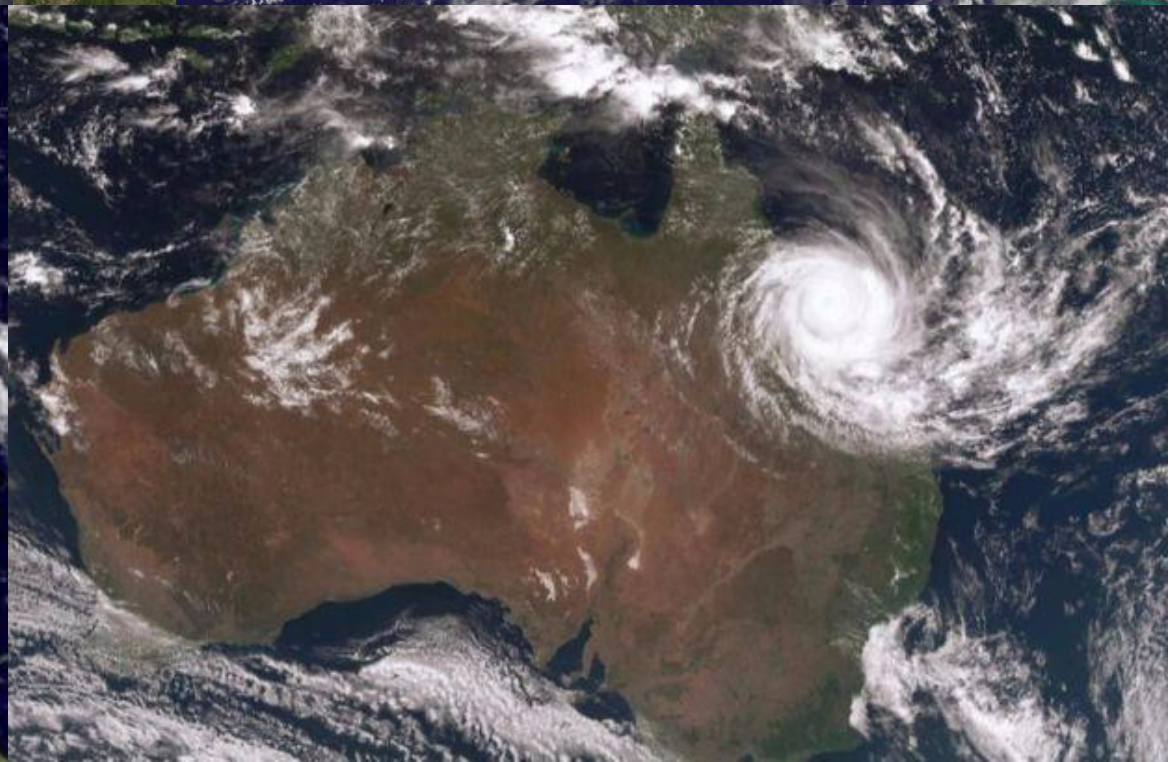


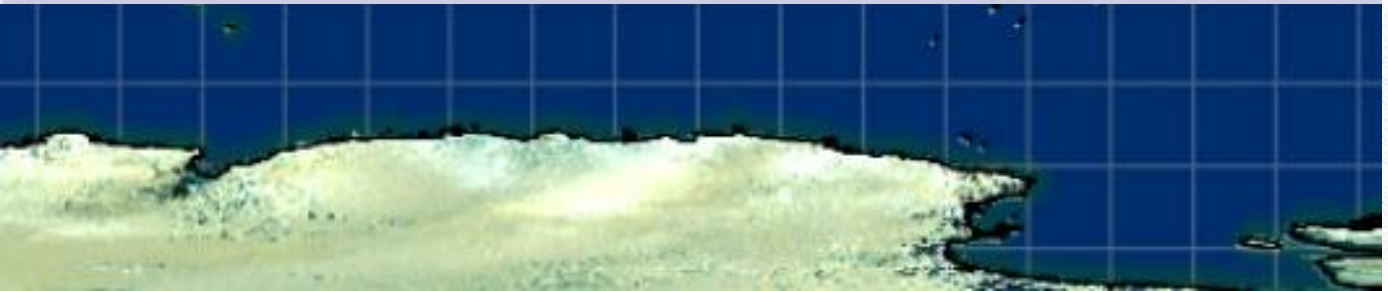
Christopher Werner

MSc Geophysical Hazards
(University College London)
MSc Climate Change
(University College Dublin)

ICHEC
Irish Centre for High-End Computing







DARWIN WIPED OUT

THE TOLL: DEAD, 49 HOMELESS, 30,000

The Sun NEWS-PICTORIAL
8c
Melbourne, Thursday, December 20, 1974

WEATHER Bureau forecast: Showers, isolated thunderstorms in the south. Very few showers in the north. * Details — P.22.

—By Tracy, the killer cyclone

By MICHAEL GAWENDA

AT LEAST 49 people died in the cyclone which smashed Darwin yesterday.

Officials say the toll could reach 100 after rescuers search rubble.

Cyclone Tracy has destroyed or badly damaged 95 per cent of the city.

Officials estimate up to 30,000 of the city's 40,000 people are homeless.

7 ships

All power is off. There is no fresh water. Makeshift camps are being set up.

Tracy's 240 kmh (150 mph) winds sank two ships and swept five others aground in Darwin harbor.

The city's hospital is a wreck — with the roof ripped off.

The hospital patients were taken to safer places.

The police station and post office also are wrecked.

All hangars and 80 per cent of the terminal buildings at Darwin airport are smashed.

Runways are strewn with rubble.

Phone and teleprinter links with the city were cut.

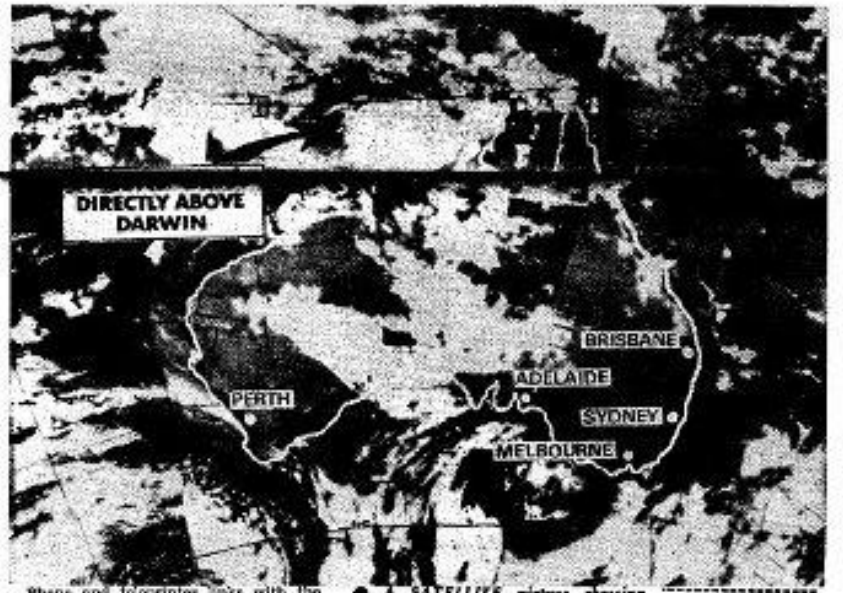
Hundreds of shocked people wandered wreckage-jumbled streets.

The Acting Prime Minister, Dr Cairns, said last night, "This is a national disaster."

He will fly to Darwin today.

A big Federal Government relief operation was under way last night.

A pilot who flew over the city said it was wrecked. Roofs were ripped from



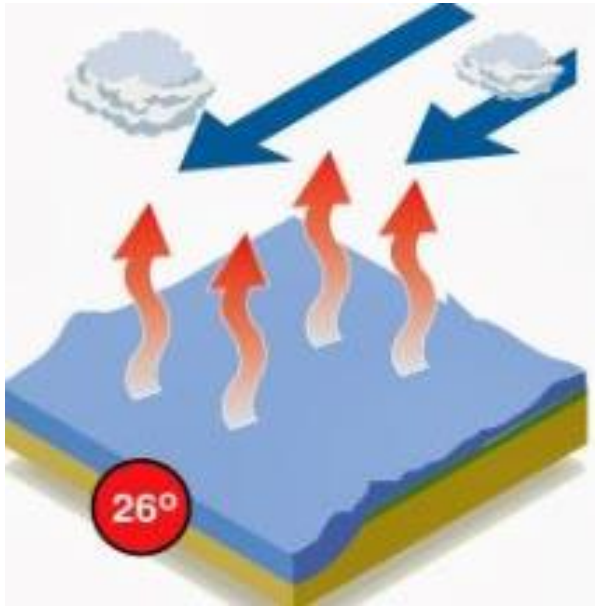
* A SATELLITE picture showing Cyclone Tracy centred over Darwin. It was taken from the Esro-8 satellite from 1200 kilometres (745 miles).

They need our help...

THE SUN and The Herald will launch a public appeal to help victims of the Darwin disaster.

Cairns on the way

* At 5 a.m. the Acting Prime Minister, Dr Cairns, will fly to Darwin to the disaster scene. — Report P. 2.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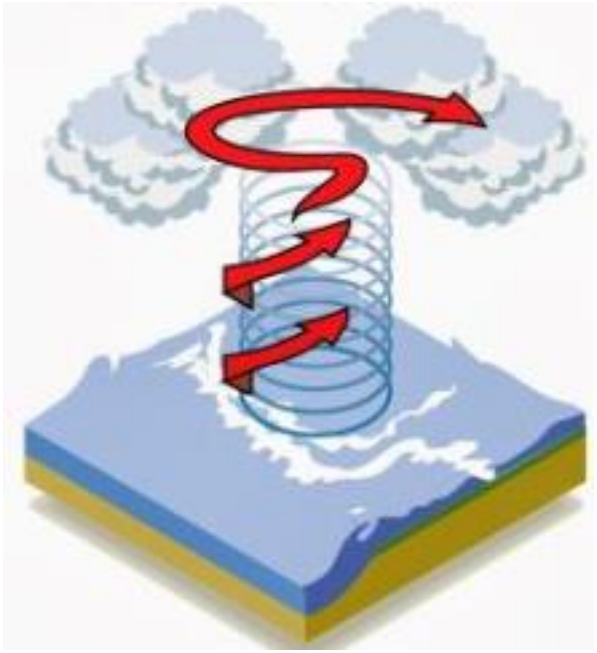

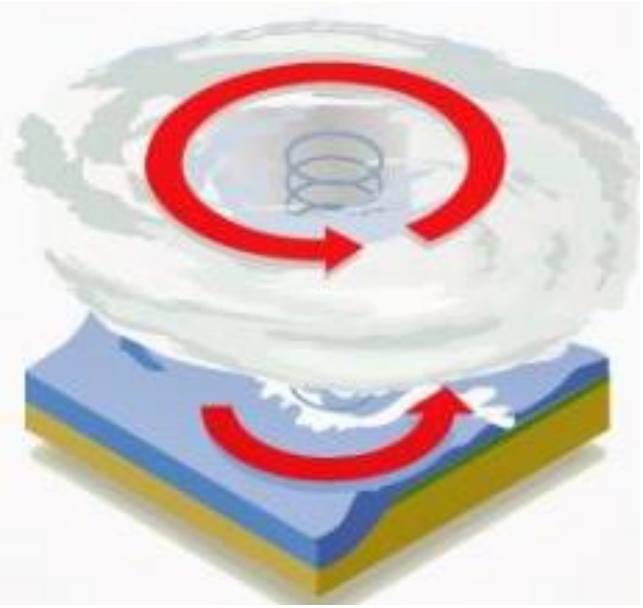

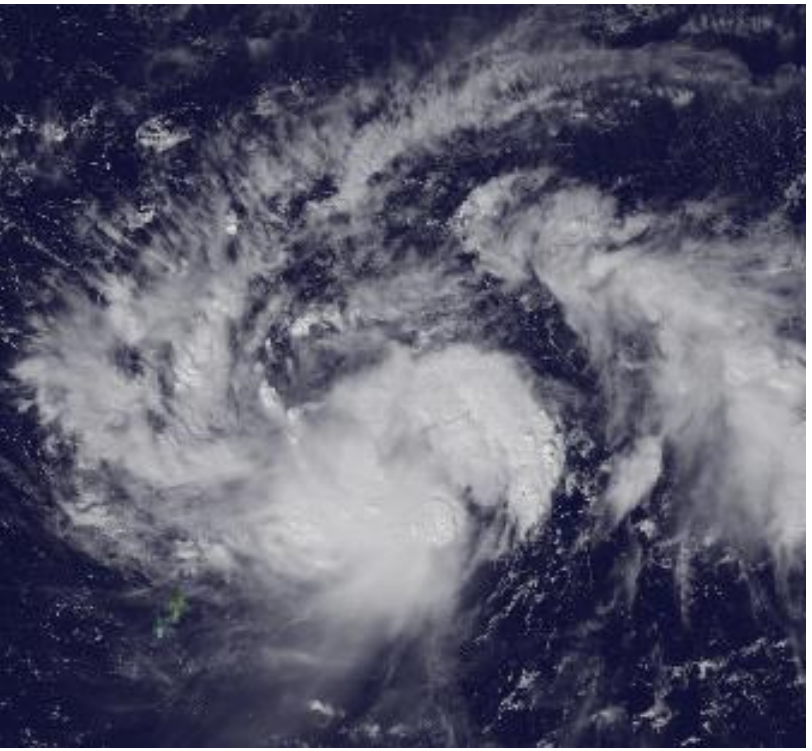

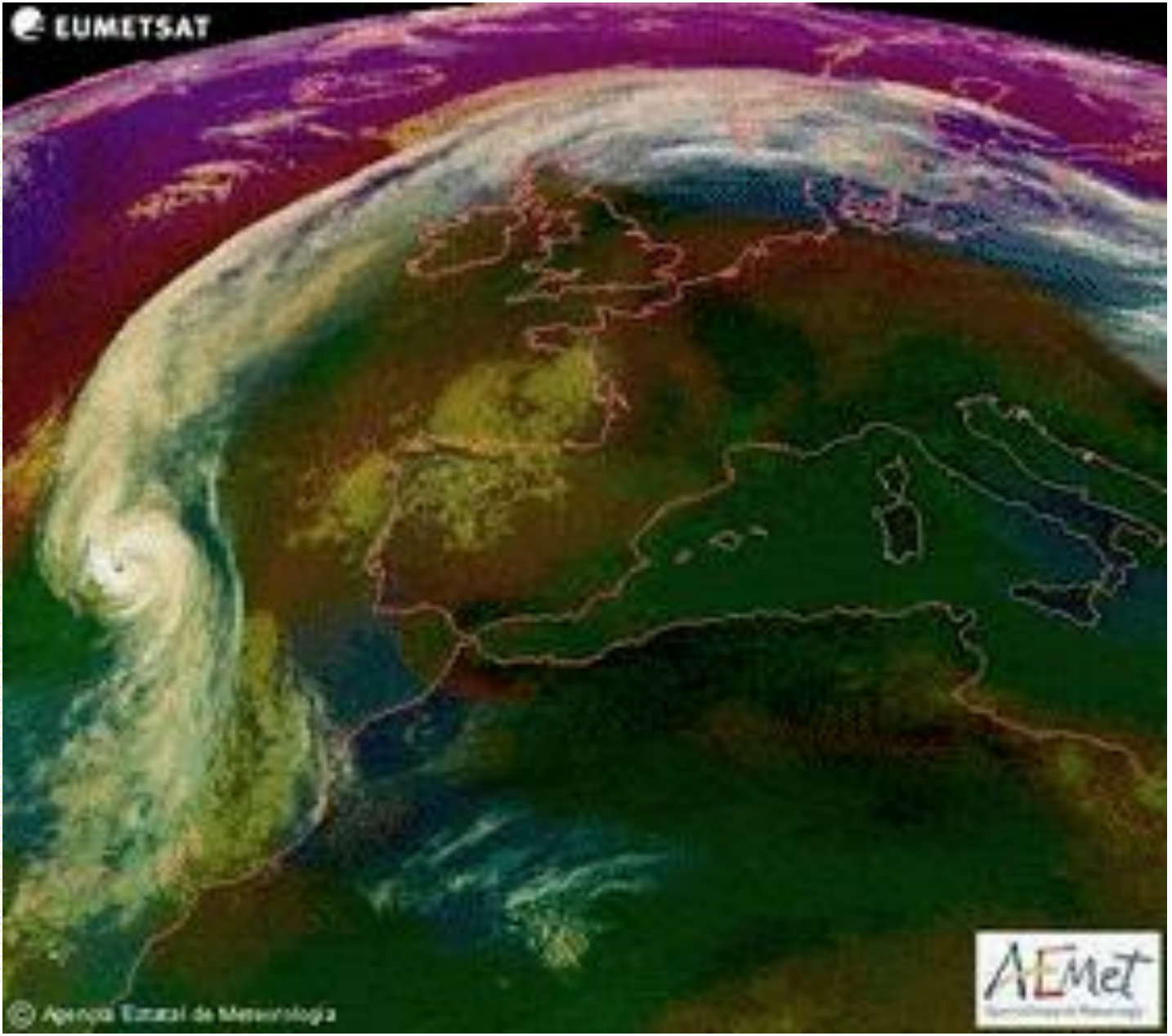
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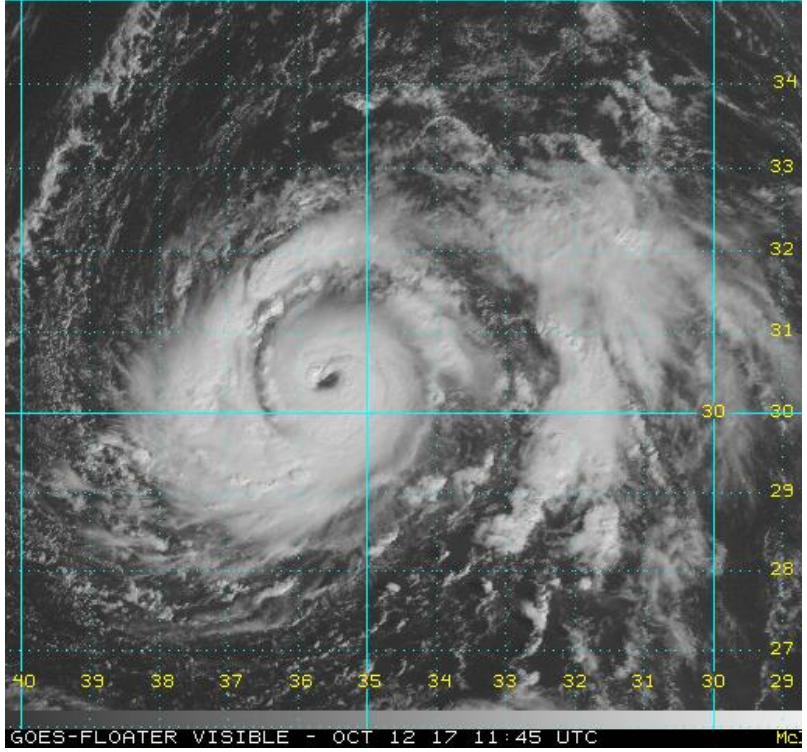
© Agencia Estatal de Meteorología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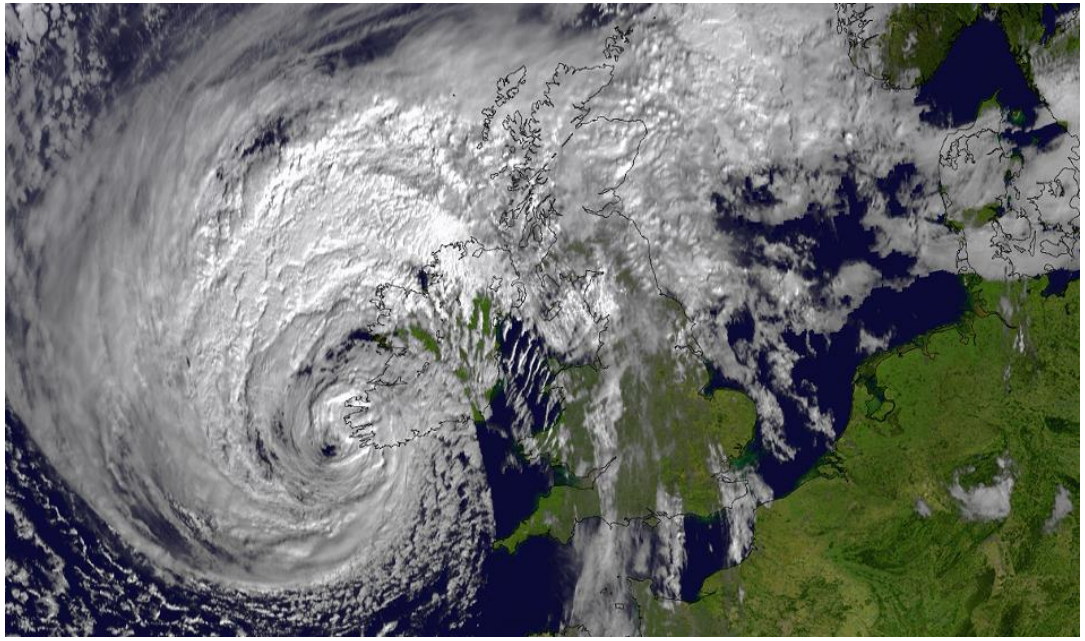
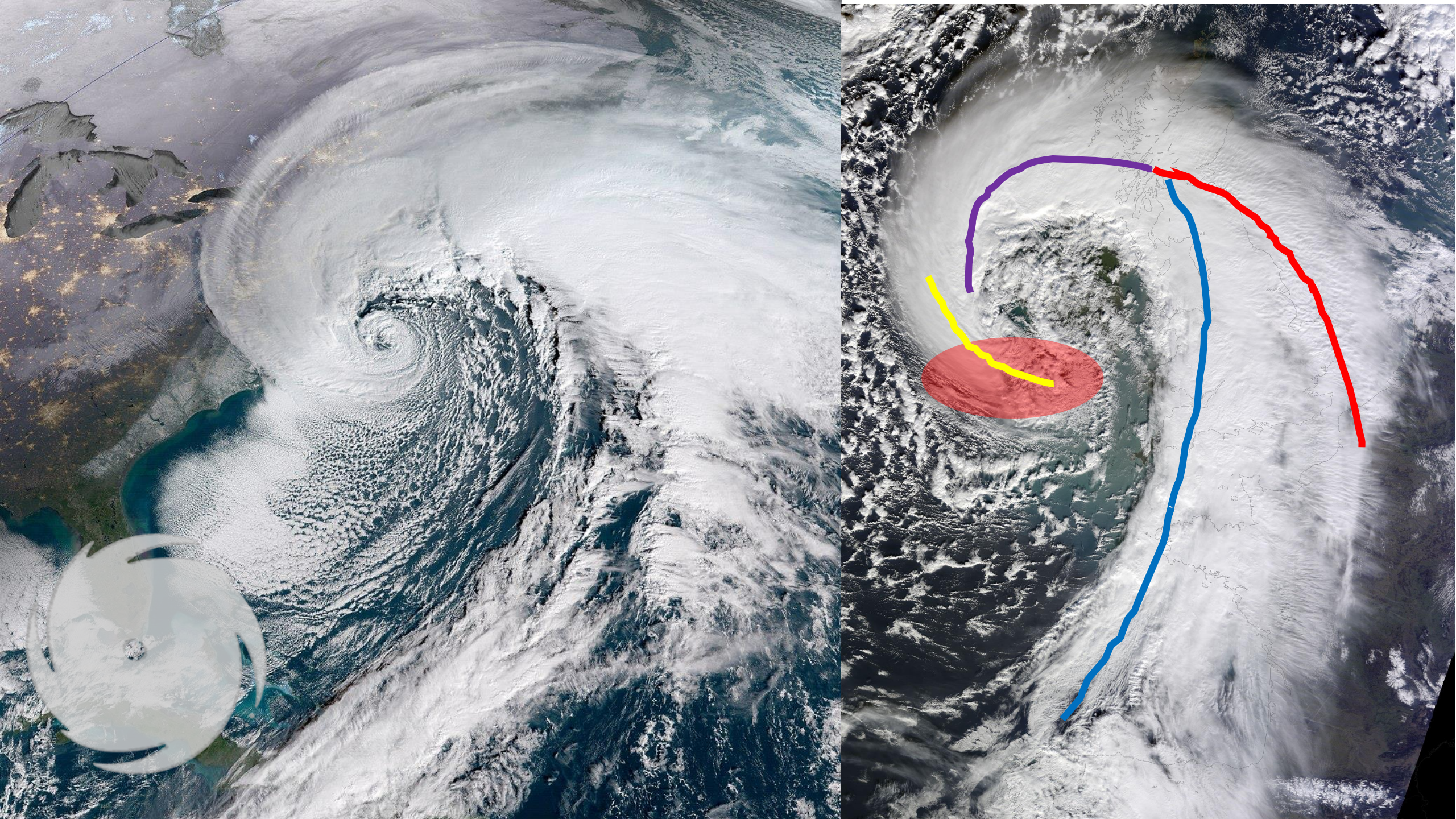
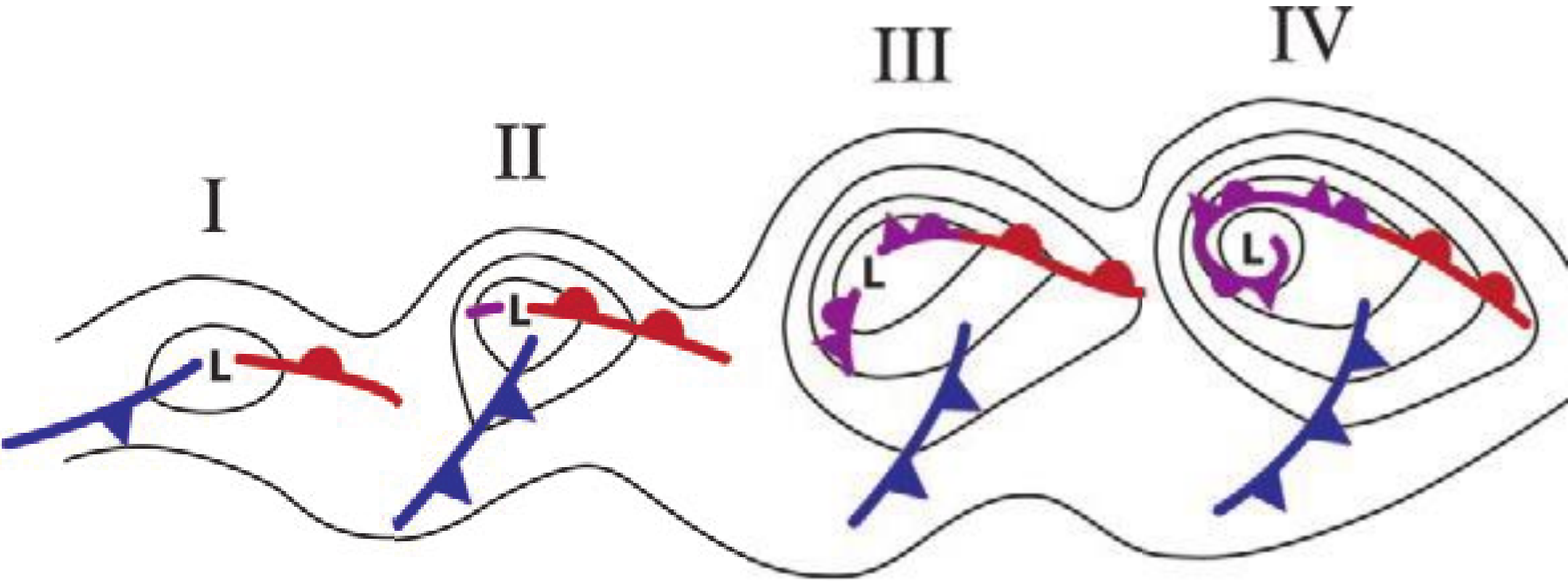






Open Wave Frontal Fracture T-Bone Mature (Seclusion)

Daily Mail
WEDNESDAY, AUGUST 15, 1979
9p (CHANNEL ISLANDS 10p)

MONEY MAIL: PAGES 15-22

16 lives feared lost . . . 22 boats missing as a near hurricane hits yachtsmen

FASTNET RACE OF DEATH

By CHRISTOPHER WHITE and WILLIAM LANGLEY

A SEA disaster unparalled in yachting history turned the Fastnet Race, the stern climax to Cowes Week, into awesome tragedy.

Across hundreds of miles of ocean some of the world's finest yachtsmen died or went missing in a sea whipped up into frenzy by winds near to hurricane force.

In a matter of hours, many of the fleet of 335 boats, which included some of the most expensive yachts afloat, were scattered, crippled or sunk.

Late last night the official death toll was nine, with at least another seven missing: 114 people had been rescued, including several women.

Twenty two yachts were reported sunk or abandoned. Others like Morning Cloud, skippered by ex-Premier Edward Heath, were limping to port. Morning Cloud is expected in Falmouth at noon today.

It was a night in which the sea took on and conquered the thoroughbreds of the yachting world.

It was a night which knew heroism and fear as yachtsmen who thought they had experienced every kind of element suddenly found themselves up against forces beyond them.

Boats turned right over. The lucky ones righted themselves again.

Yachtsmen were thrown into the dark waters. The lucky ones were held by their safety harnesses and were pulled back.

The airwaves were alive with Mayday distress calls. The lucky ones were reached in time by the desperately over-stretched rescue services.

Courage

Last night with the winds moderating but with the sea still dangerously high, an RAF Nimrod jet ceaselessly patrolled the area along with four Sea King helicopters from RNAS Culdrose, the fishing protection vessel Anglesey, the frigate Broodsword and two naval tugs.

One hundred of the 300-plus yachts had been accounted for.

Meanwhile, as hour by hour went by, the lists on the window of the race office in Plymouth reported sightings length-

Turn to Page 2, Col 1


A Royal Navy winchman is lowered to a life-jacketed crewman of the yacht Ariadne

---

rport
gedy

eople were when their aircraft ed just mi- fter taking off eted Airport sday. olden Eagle 421 plane, by Hasting- otels, came just after t Hatfield half a mile airport.

work
chools

officer

Second crisis in a week


Donald and Jane Benson outside their home after the hurricane

Worst winds for 300 years

by Nick Jones

SAFFRON Walden is this week clearing up the wreckage in the wake of hurricane havoc which at one point on Friday had the town totally sealed off from the outside world.

"The worst crisis to hit South East England since the end of the war" was how Home Secretary Douglas Hurd described ferocious winds which uprooted trees and knocked out power-lines.

It was a view the emergency services would subscribe too.

"At one time all the roads in and out of Saffron Walden were blocked," said Inspector John Emmerick of Saffron Walden Police.

"I've been about a long while and it's the worst conditions I can remember."

The wind gusting to well over 100 miles per our struck in the early hours of Friday morning.

Weather forecasts had predicted only mild breezes the previous evening but by the morning many householders were left to pick up the pieces following the highest winds recorded in 300 years.

The situation was so bad on Friday morning that the police had to call in the army to help clear up the chaos.

"Without the Royal Lancers from Carver Barracks we would still be cut off," said Inspector Emmerick.

"They sent out teams with chainsaws and axes and we owe them a great debt."

"We'd just breathed a sigh of relief after the floods," said Inspector Emmerick, "and then all this."

On Monday the Inspector believed there was still a road blocked at Chesterford and some outlying villages were without electricity.

For the electricity board it was a sleepless weekend as they battled to reconnect the region's power supply.

"It was the worst crisis to hit this industry," said Eastern Electricity's distribution engineer Geoff Stott.

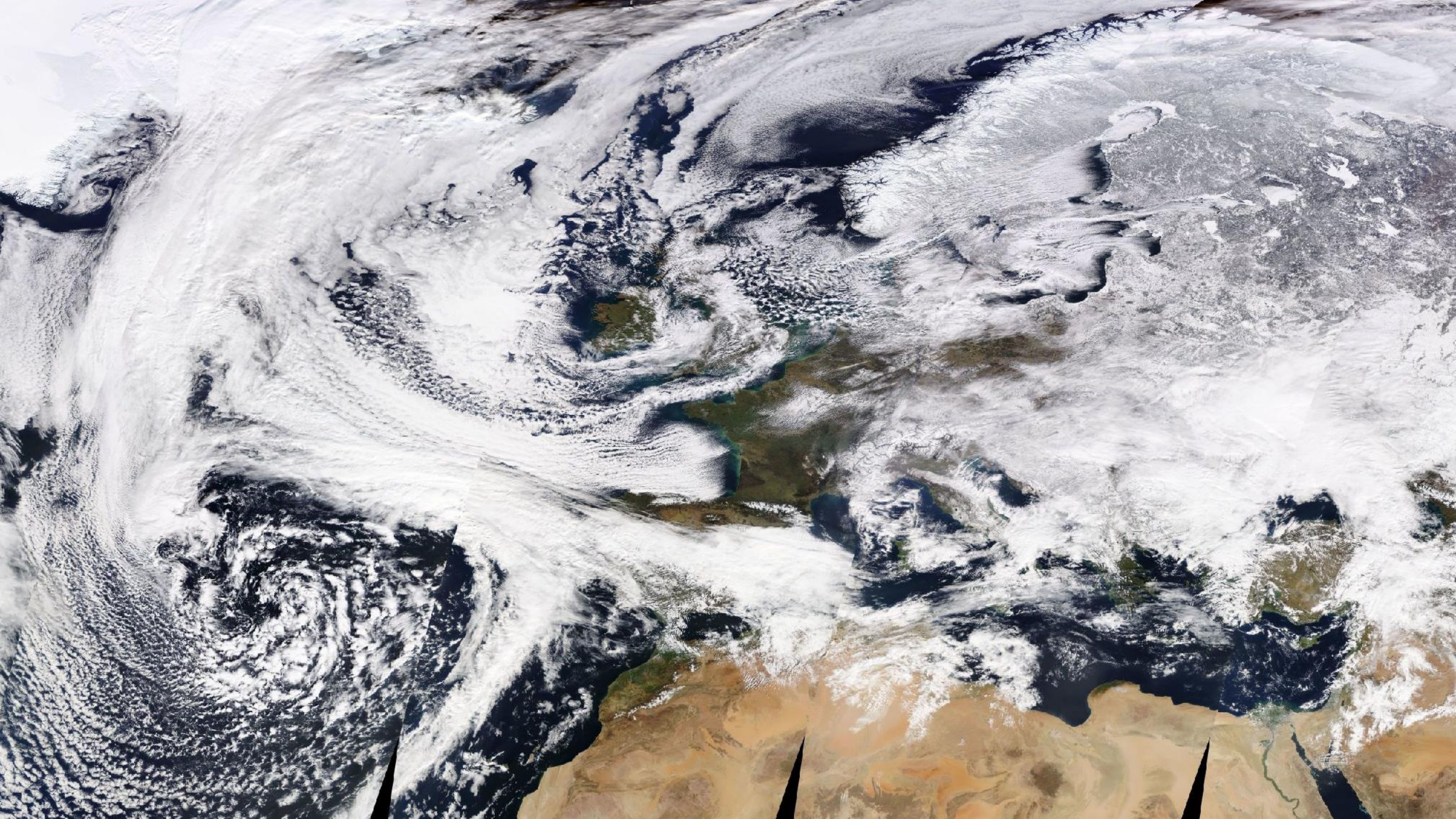
By Monday morning there were still between 1,000 and 1,500 homes without electricity as the engineers battled to get everyone back on stream.

Briefly

Deputy leaves

Clocks go bac

DON'T forget you hour in bed, wh clocks go back o on Sunday, Octob 2 am, marking th British Summer T



- Form in tropics
- Higher winds, smaller area
- Temperature remains similar throughout storm
- Form from very warm water
- Dissipate quickly over land
- Hazards: High winds, rainfall, landslides, surge

- Form in extra-tropics and from tropical storms
- Lower winds, larger area
- Always have fronts
- Form along temperature gradients
- Do not dissipate as a result of landfall
- Hazards: High winds, rainfall, surge, landslides, blizzards

GUY CARPENTER

Understanding catastrophe modelling
Inputs, outputs and the future

14 March, 2018

Paul Jones

Dublin

MARSH & McLENNAN COMPANIES

COMPANY BACKGROUND

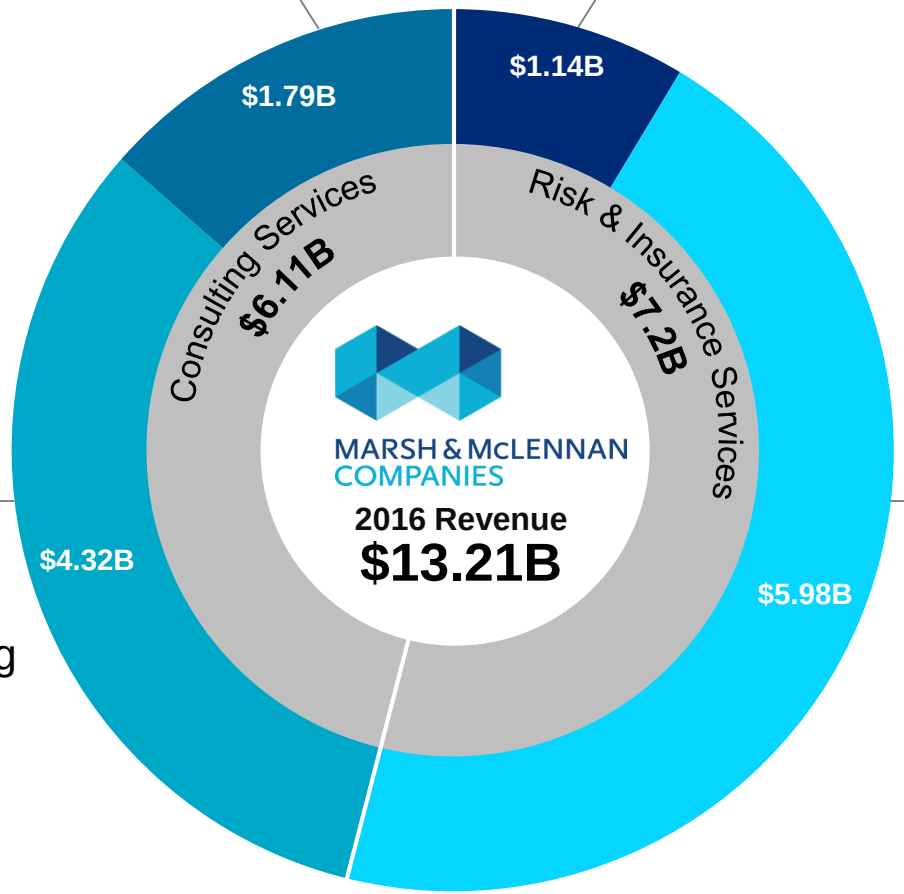
Marsh & McLennan Companies

OLIVER WYMAN

Management Consulting

GUY CARPENTER

Reinsurance and Risk Management



MERCER

Talent, Health, Retirement and Investment Consulting

MARSH

Insurance and Risk Management

Well Positioned to Help Our Clients Achieve Success

EXPERIENCE

Placed **$30.4 billion** in ceded premium for **2,400 clients in 2017**

REACH

Our **2,300 employees** sit in **over 60 offices** in **35 countries**

IMPACT

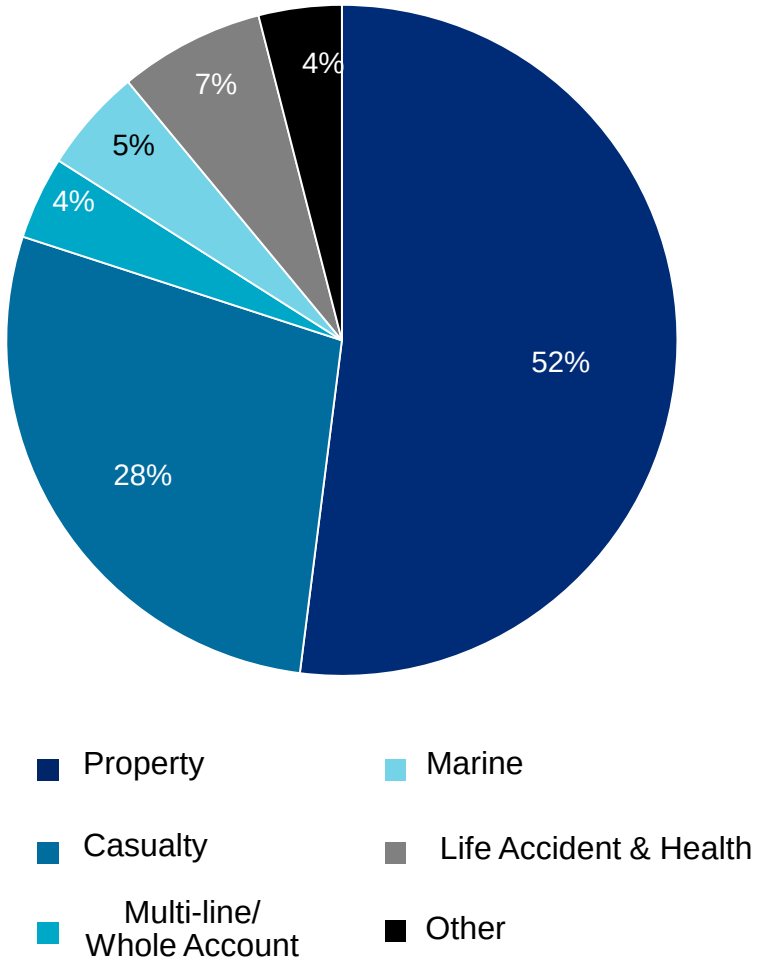
Deliver a powerful combination of:

1. **Broking expertise**
2. **Strategic advisory services**
3. **Industry-leading analytics**

STRENGTH

Part of Marsh & McLennan Companies, a **$13 billion professional services firm, since 1923**

Ceded Premium by Line of Business



Reinsurance Broking

Guy Carpenter delivers deep technical insights and vast transactional capabilities to address complex and unique risk management challenges.

- Reinsurance brokerage services provided for over 90 years and we continue to serve some of our original clients
- Line-of-business experts deliver deep market knowledge and efficient transactions in every relevant geography
- We have unmatched market intelligence as well as capacity and pricing advantage
- Continuous benchmarking across markets informs the most effective structures and timing for each client's coverage requirements

We help clients anticipate and navigate change, providing them with a business edge that goes beyond best pricing in the reinsurance market.

Account Team

Irish Focused Reinsurance Team

BROKING TEAM

Paddy Ryan
Managing Director

Turlough Ryan
Assistant Vice President

GC ANALYTICS

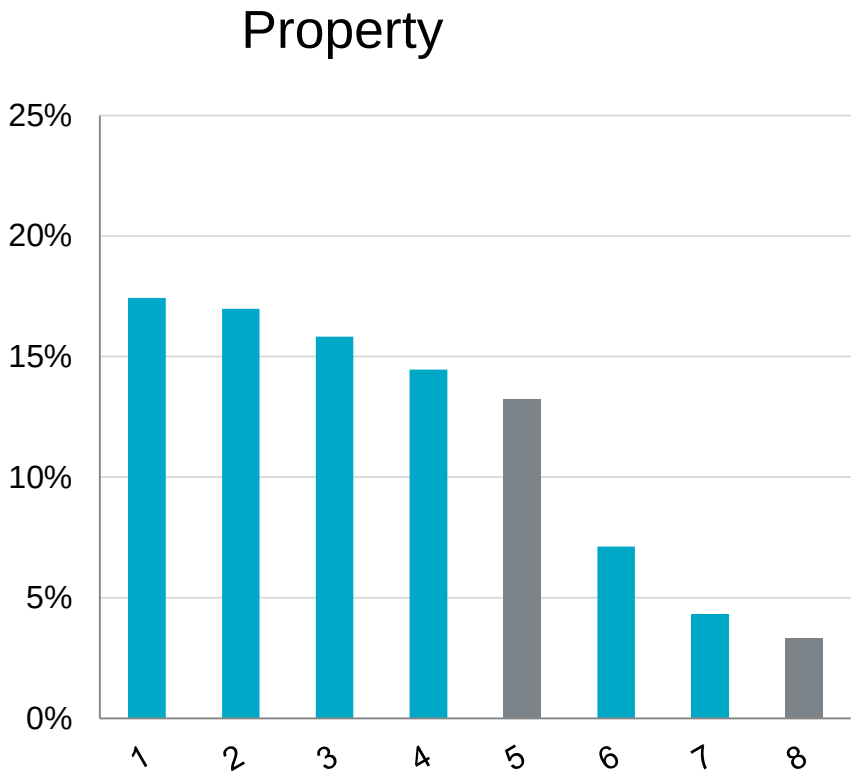
Paul Jones
GC CAT Modelling

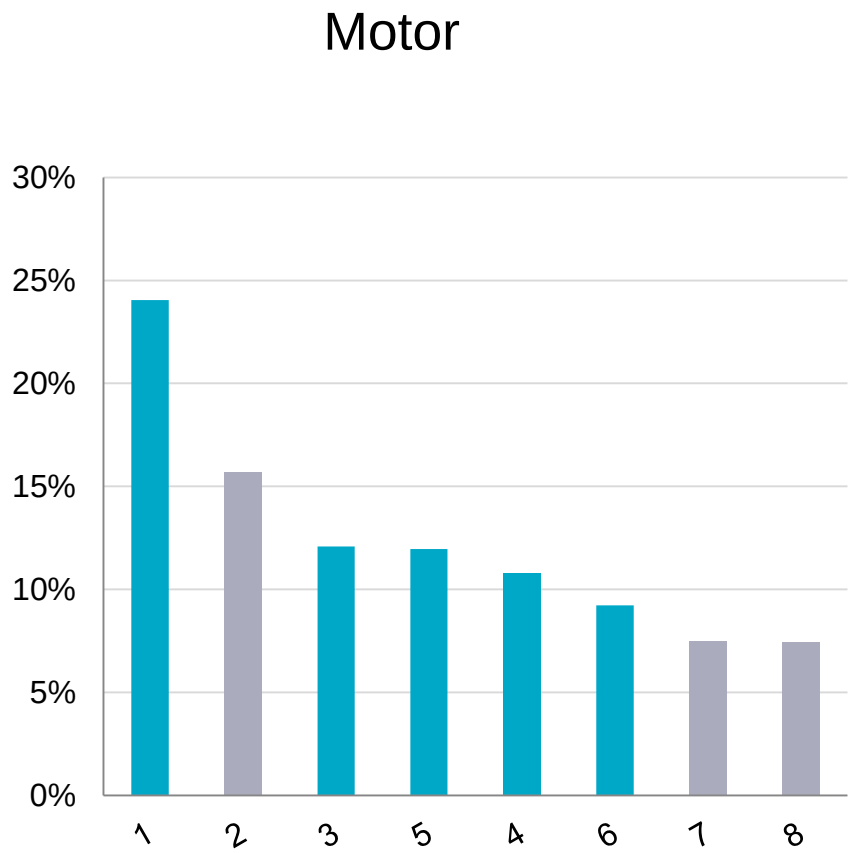
Amrita Pattni
GC Analytics

Henry Medlam
GC Analytics

Presenting today

Market Share





AGENDA

INTRODUCTION

CATASTROPHE MODELS

PORTFOLIO DATA

MODEL SUITABILITY ANALYSIS

THE FUTURE

A View of Cat Risk to underpin all business decisions

Reinsurance Strategy	• Structure, Pricing, Benchmarking
Gross Loss Modelling	• Actuarial, Catastrophe Modelling
Capital Modelling	• Regulatory, Internal Model, Standard Formula, Allocation
Underwriting	• Natural perils and man-made
Portfolio Management	• Accumulations, scenarios, planning, post event response

Leading Analytics Empower Risk-Informed Decisions

GC Expertise

Exposure Data
- Quality
- Benchmarking
- Augmentation

Vendor licenses
- RMS, AIR, Corelogic, JBA

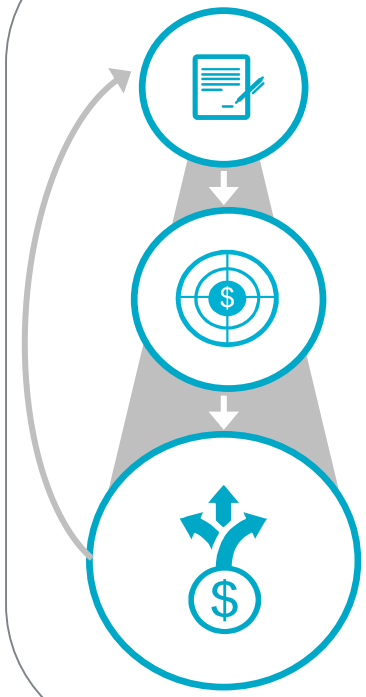
MSA
- Hazard
- Vulnerability
- Scientific assessment

Complete the Risk Landscape
- Man-made hazard
- Engineering
- Freeze Modelling

Delivering Analytics
- OASIS
- AdvantagePoint

Own View of Risk

Where we can help our clients



UNDERWRITING ANALYTICS
- Risk Level Underwriting
- Strategic Growth Advisory
- Underwriting Strategy

→ **MAXIMIZE PROFITABLE GROWTH**

PORTFOLIO ANALYTICS
- Structure and Placement
- Portfolio Risk Management
- Cat Response & Claims Analytics

→ **CONFIDENTLY MANAGE RISK**

STRATEGIC RISK & CAPITAL MANAGEMENT
- Develop client view of risk
- Satisfy regulatory validation requirements
- Embed OVoR in internal model for managing capital and earnings volatility

→ **OPTIMIZE RETURN ON CAPITAL**

CATASTROPHE MODELS

Risk Landscape - Global Evolution

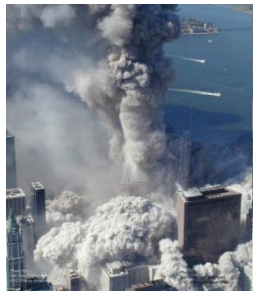
2 1992 – Hurricane Andrew
- Models Go Worldwide
- Influence Rate Adequacy
- Rating Agencies Empowered

4 2005 - Katrina
- Re-adjust Frequency, Severity assumptions
- Rating Agency Increases Capital Requirements

6 2014 – Solvency II

5 2008 – Financial Crisis
- Enterprise Risk Management
- Increased Regulatory Oversight

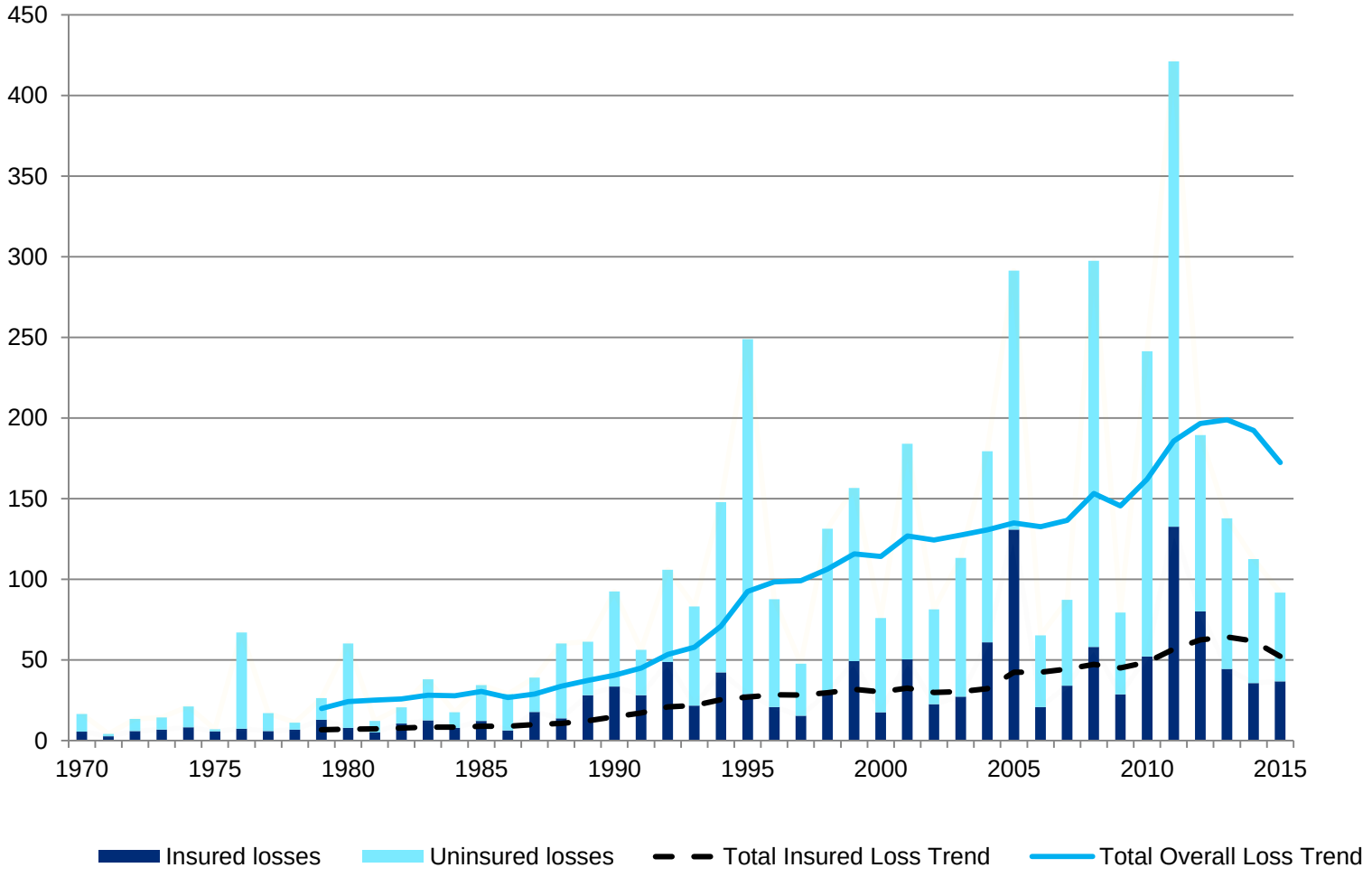
3 2001 – 9/11 attacks
- Loss Correlation
- Data Rapidly Improving
- Capital Markets Enter into Reinsurance



1 1970 & 80s
- Poor Data
- Limited Models
- LMX spiral
- Lloyd's collapse

After each market turning event, the industry realised it had more exposure than previously thought

Risk Landscape - Global Natural Catastrophes Losses (1970-2015)



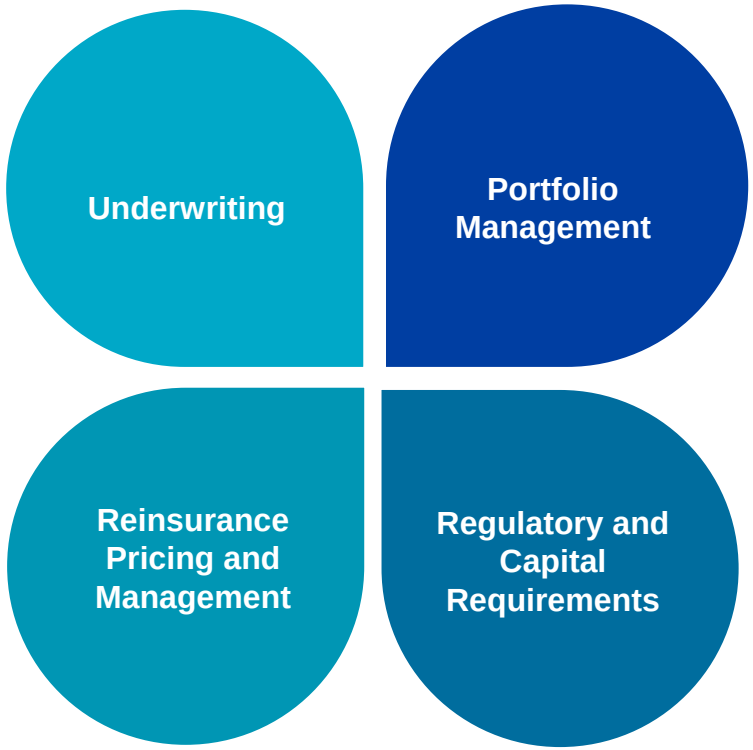
Source: Swiss Re Economic Research & Consulting and Cat Perils

Catastrophe Modelling

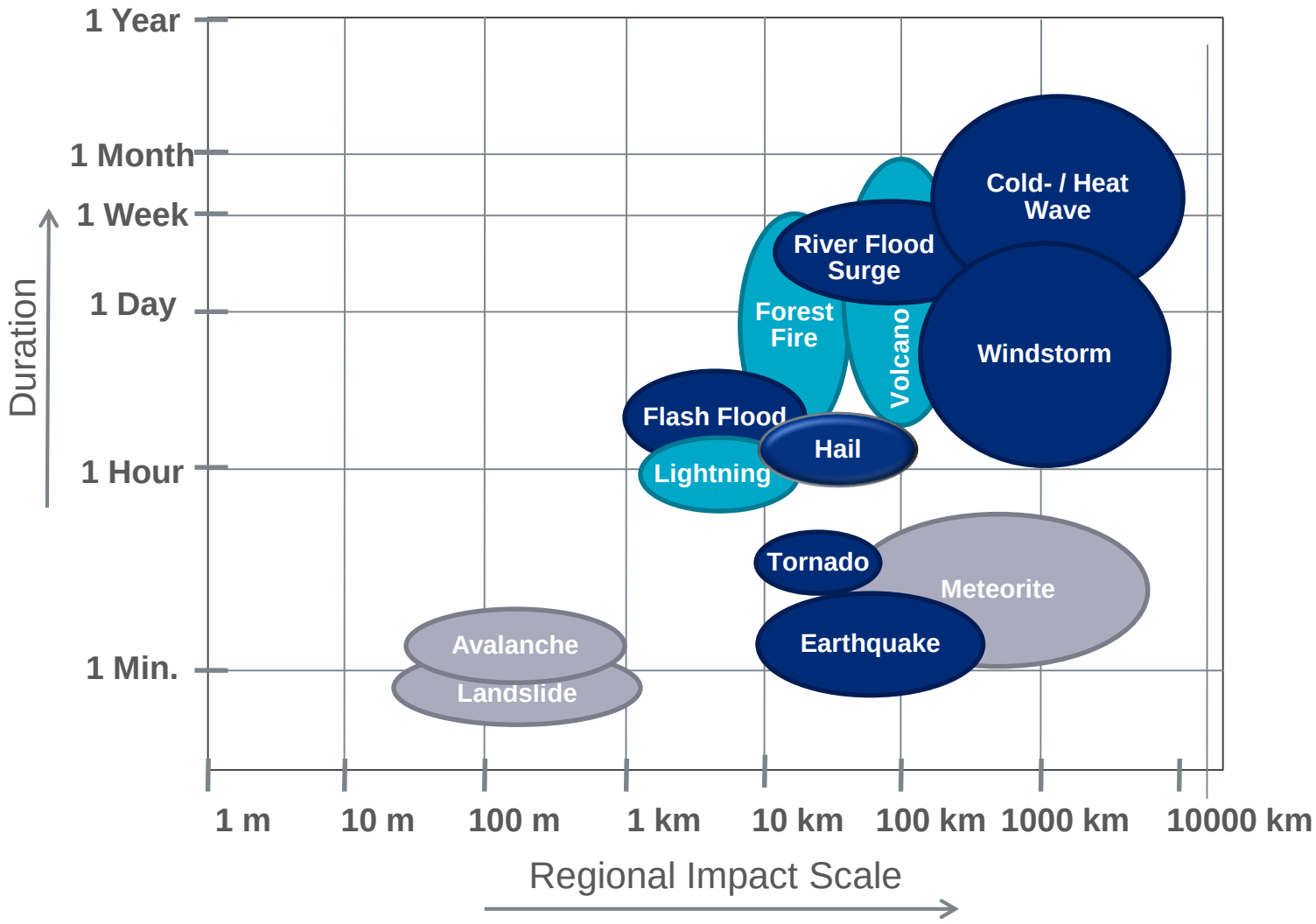
Process of using computer-assisted calculations to estimate the losses that could be sustained due to a catastrophic event such as a hurricane or earthquake:

- The process **does not predict** natural catastrophes!
- Provides a framework for understanding the types of events and losses that could be experienced but may not yet been experienced

Applications



Types of Natural Perils



Modelled Global Perils

Flood

Hurricane/Wind

Earthquake

Hail

Terrorism

Tornado

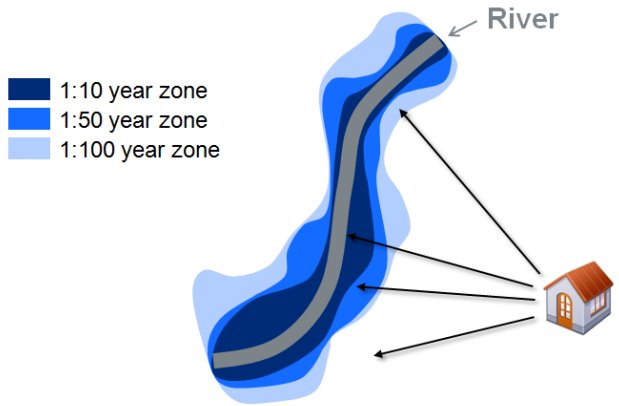
Wildfire

Storm Surge

Types of Natural Catastrophe Models
Different Tasks Require Different Types of Models

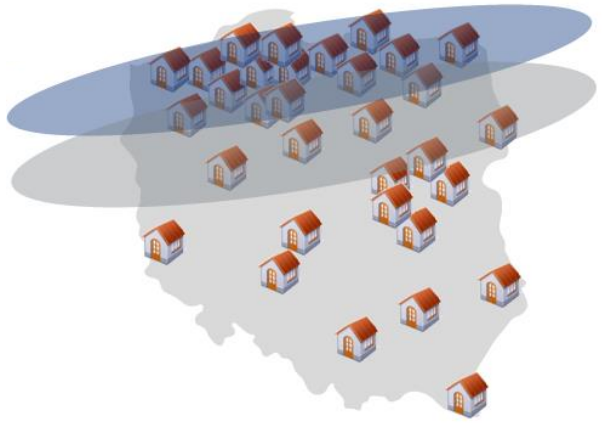
Zonation Models

- **Should I underwrite a risk?**
- **What should be the rate?**
- **Should I impose a deductible and/or limit**



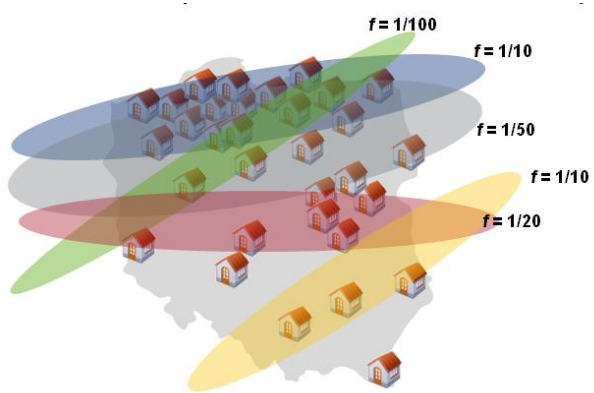
Deterministic Models

- **What-if Daria was to happen again?**
- **Calibration/validation of probabilistic models**
- **Scenarios, what would happen if Ophelia affected Dublin?**

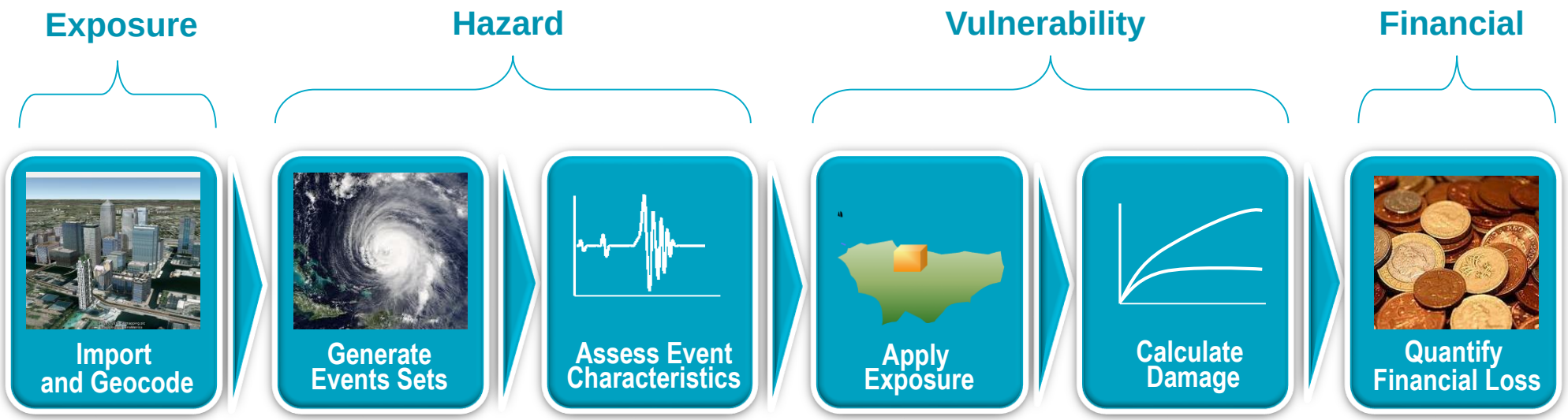


Probabilistic Models

- **What is the value of the modelled peril?**
- **How much reinsurance should I buy?**



Probabilistic Catastrophe Modelling Components



Results of a Probabilistic Model

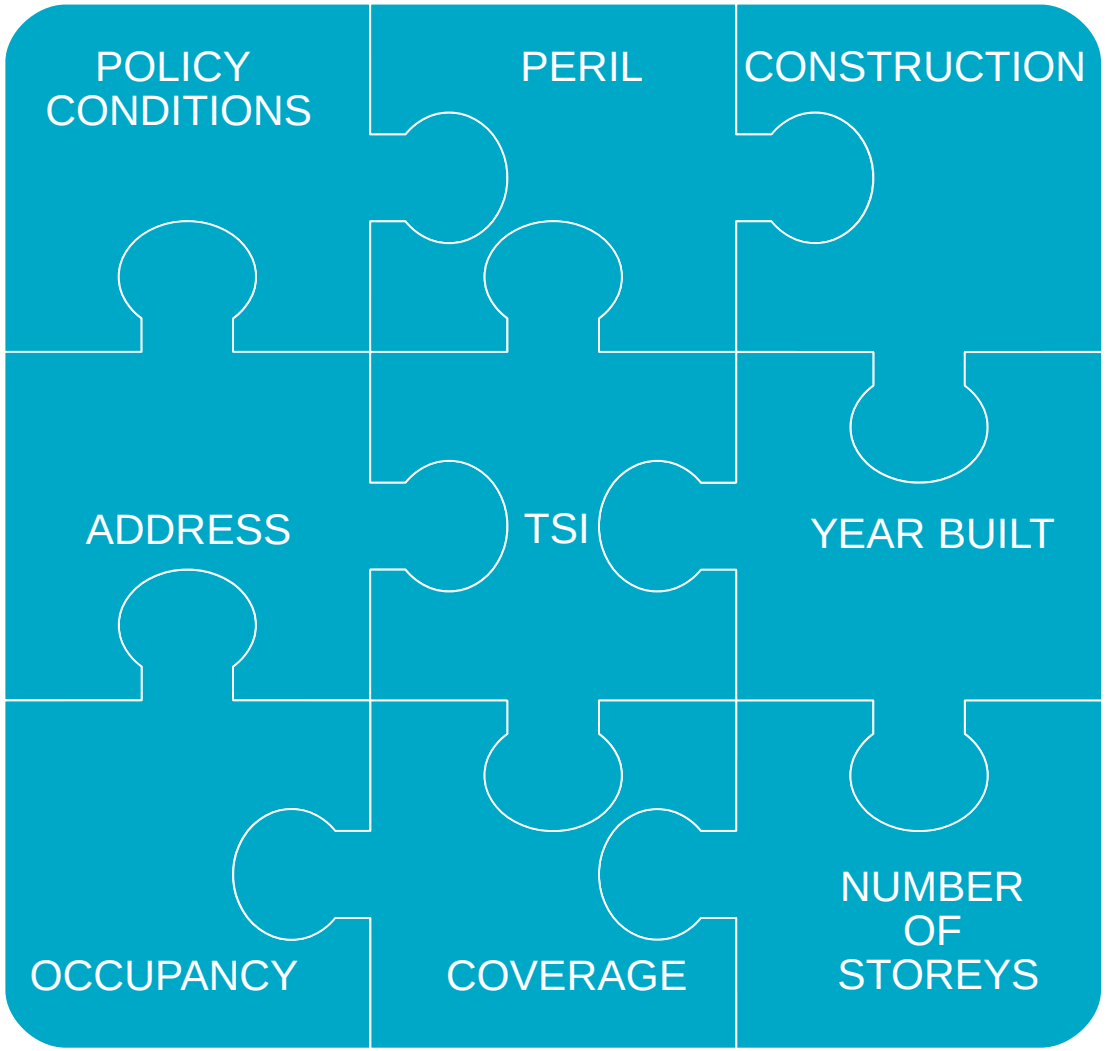
- EPs can be based on
  - Annual losses ⇨ Annual Exceeding Probability (AEP)
  - Per Occurrence Losses ⇨ Occurrence Exceeding Probability (OEP)
- Often “AALs” are used as risk measurement
  - AAL = Average Annual Loss (= technical premium)
  - Statistical mean of the annual loss distribution
- Loss Perspectives
  - Ground-Up = Damage
  - Gross = Loss after applying limits & deductibles
  - Net = Loss after applying reinsurance treaties to gross loss
- Event Loss tables (ELT) and Year Loss tables (YLT)

Vendor Catastrophe Models
Irish Models

RMS	AIR	Others
Windstorm Model for Ireland as part EU WS model. • 2018 New Models – Extension of EU HD FL model to Ireland in 2018 – EU SCS model 2018	Windstorm Model for Ireland as part EU WS model. • 2018 New Models – EU WS model (including Ireland) 2018 – EU SCS model 2018	CoreLogic have EU WS model. Other Vendors such as JBA have risk products that cover Ireland

PORTFOLIO DATA

Portfolio Data Inputs

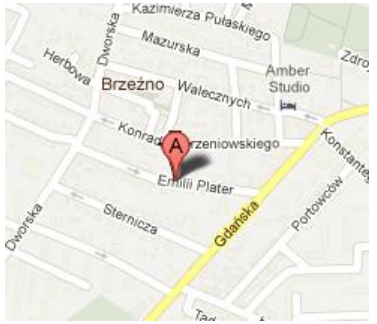


Data Completeness
Affects the assumptions a model may make

Higher data resolution for detailed perils can have a significant impact on modelled loss

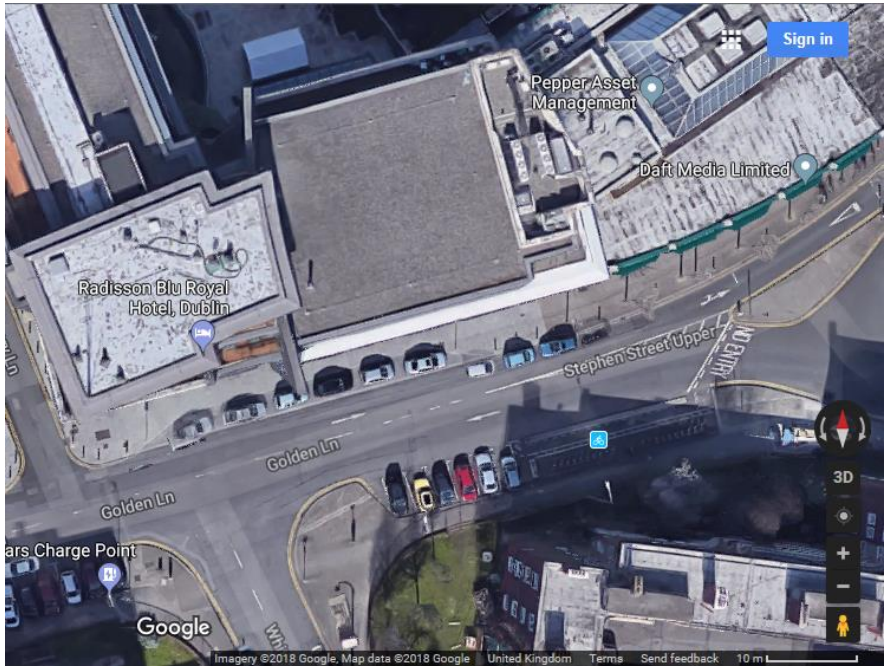
- Low spatial and attribute resolution
  - Relies on model assumptions for distribution of exposures
  - Performs poorly for high resolution hazards like flood

- High spatial and attribute resolution
  - Allows the model to reflect portfolio characteristics
  - Only danger is over-parametrization



Location Data
Geocoding

- Location of the risks in a coordinate or zonation system
- Ireland geocoding has been traditionally zonal (at County)
- Systems may not have been designed to capture the detail required with the validation needed
- General consensus is that under GDPR an address is potentially personal information, so transfer of the information to modelling systems has risks
- For windstorm location is less important to modelled loss but perils such as flood have significant sensitivity



- **Conceptually simple but in some cases operationally difficult**
- **Legacy systems can impact companies ability to capture the right information**

Location Data
Occupancy Type

Single Family	Apartment	Commercial
		
Non-Engineered Structure	Marginally Engineered Structure	Engineered Structure

Location Data
Construction Type

Masonry	Steel	Reinforced Concrete
		

Source : AIR Worldwide Corporation

Location Data
Other building attributes

Low-Rise 1 - 3 stories

Mid-Rise 4 - 7 stories

High-Rise > 8 stories

Source : AIR Worldwide Corporation

Location Data
What can you control

All modelling is based around *assumptions* related to the hazard, vulnerability and the exposure. Control the model by improving the information content which will reduce the assumptions and uncertainty in the analysis.

Hazard

- Location
  - Address, Lat/Lon, Postcode, County

Vulnerability

- Occupancy & Construction
  - Secondary characteristics such as year built and number of storeys

Financial Conditions

- Limits and values by coverage
- Deductibles
- Reinsurance details

MODEL SUITABILITY ANALYSIS

GC Strategy – Model Evaluation

Don't just go and build another model for an already widely covered peril

Instead we aim to understand models and what drives differences

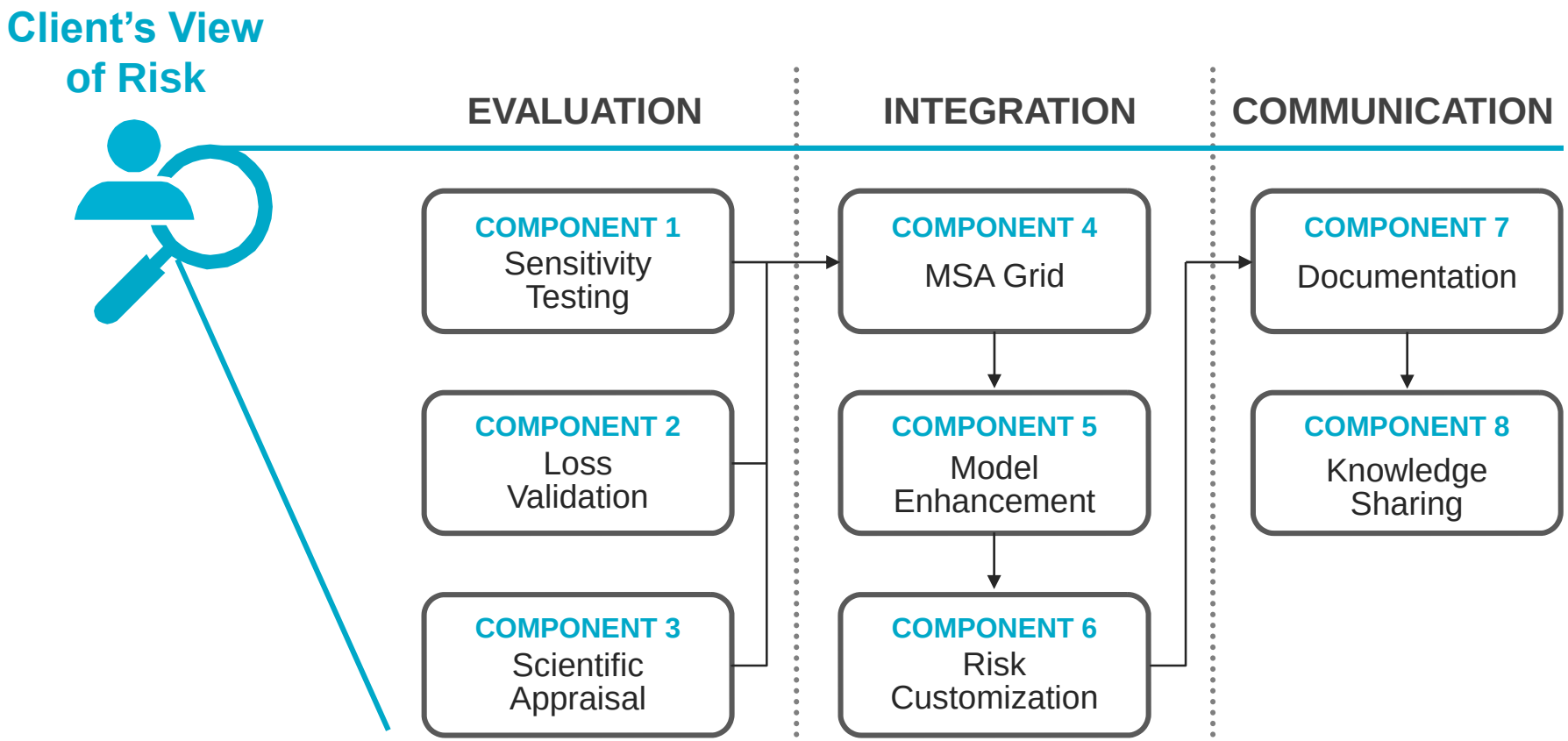
Ensure we make best use of models

- Sensitivity of exposure data attributes
- Sensitivity of modelling assumptions
- Support clients with data cleaning and data enhancement (e.g. 3-D)

Use a consistent and open approach to evaluate existing models

- Independent and unbiased – reference to credible scientific research and data
- Transparent
- Leverage our own expertise
- Make adjustments where supported by the analysis

Model Suitability Analysis^{SM} (MSA)

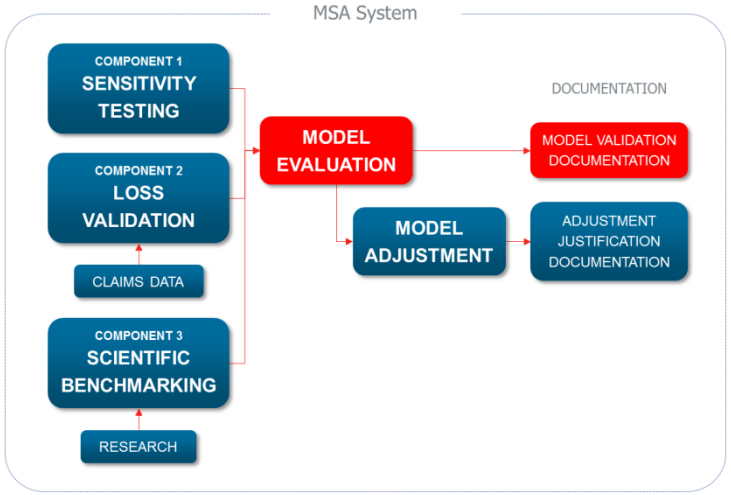


MSA Research

Our collaborators include some of the most prestigious centers of catastrophe risk research

Met Office
Australian Government Geoscience Australia
IUSS Sapere Aude
ImageCat
Colorado State University
Columbia University
The Nature Conservancy
USGS
GFZ Helmholtz-Zentrum Potsdam
UOC Universitat Oberta de Catalunya
LSU Louisiana State University
KIT Karlsruher Institut für Technologie
Cambridge Architectural Research Limited
ZNES
Boğaziçi University Kandilli Observatory and Earthquake Research Institute
University of California Davis
Western
Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu
RISK Frontiers

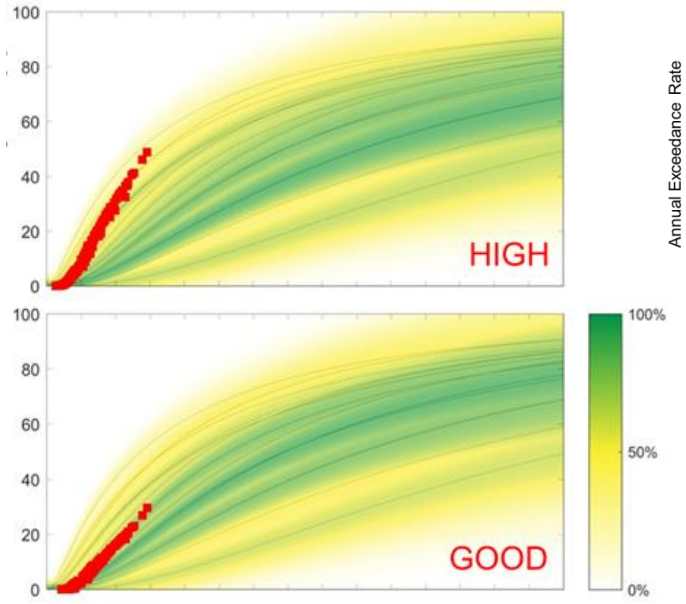
MSA in Depth – What is MSA's **Model Validation Documentation**?

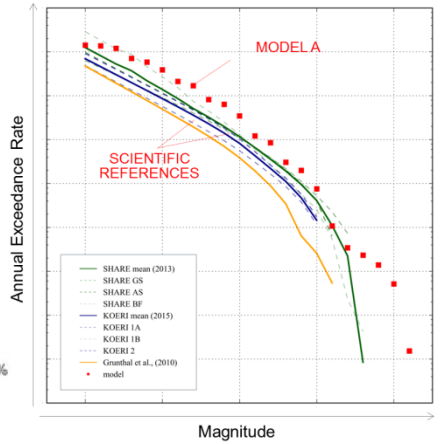


GC Client*

*Web Applications will start being accessible externally in 2017-18

All the validation exhibits a company needs to govern CAT models

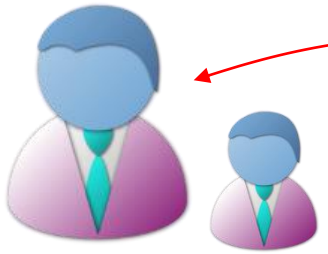




GC CATRISK SM STUDIO KNOWLEDGE BASE

GC CATRISK SM STUDIO WEB APPLICATION

Customized Tests via Browser



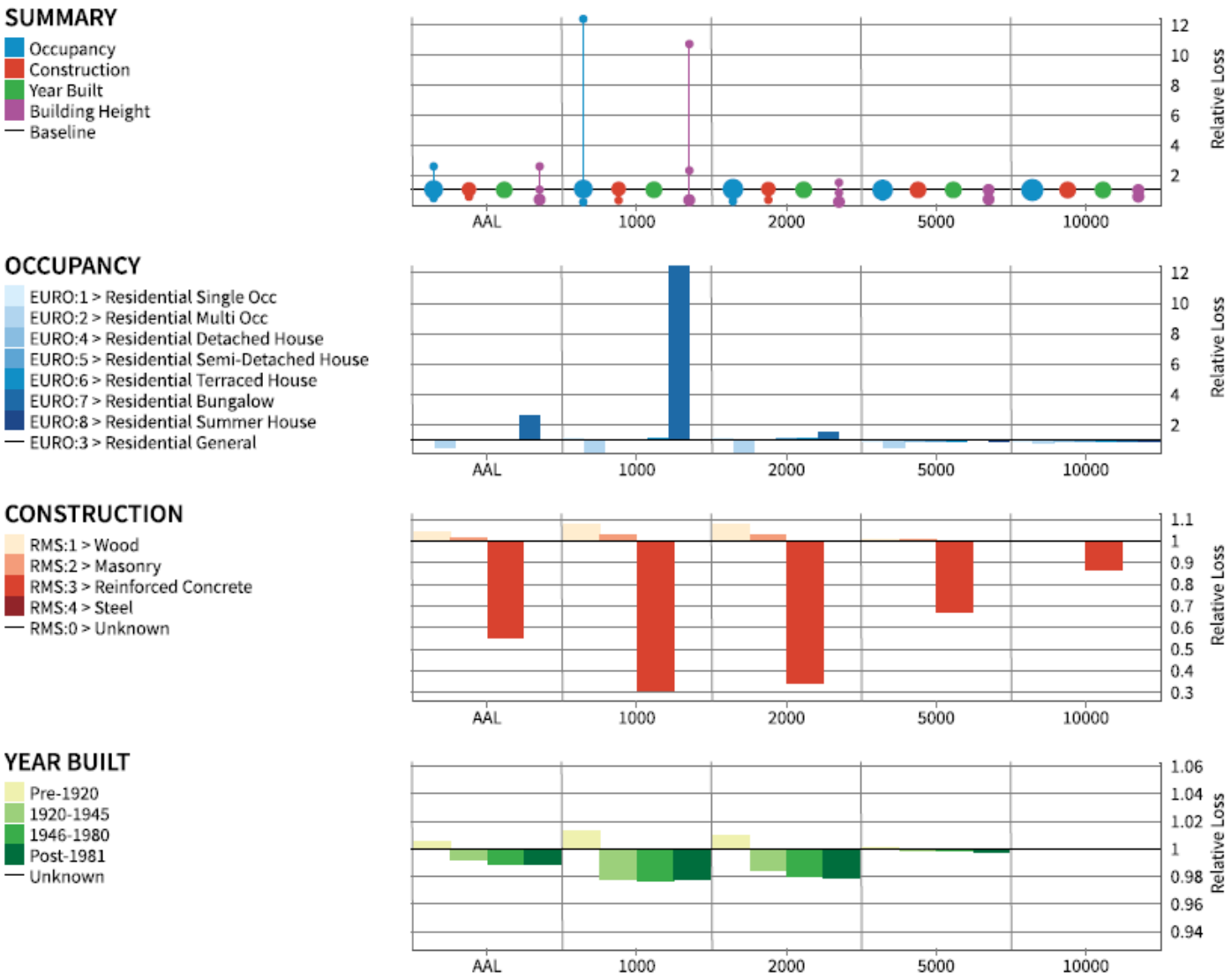
GC Colleague

We work towards an Industry Standard in Model Evaluation

EVALUATION

SENSITIVITY TESTING	LOSS VALIDATION	SCIENTIFIC APPRAISAL
C1-1 Exposure Parameters	**C2-1** Historical event loss validation	**C3-1** Historical Event Intensity Footprints
C1-2 Portfolio Specific Sensitivity	**C2-2** Historical Event Loss Distribution	**C3-2** Intensity Return Period by Location
C1-3 Industry Assumption Sensitivity	**C2-3** Reasonability of the Historical Catalogue	**C3-3** Frequency-Severity Relationships
C1-4 Clustering, Correlation	**C2-4** EP Curve Validation	**C3-4** Damage Functions

MSA– Vulnerability Sensitivity



THE FUTURE

The Future of Catastrophe modelling

Catastrophe modelling has now matured, it is now an integral part of many Brokers, Insurers and Reinsurers business processes.

- HD modelling techniques
  - Higher temporal and spatial resolution models using cloud based processing scale
  - Increased frequency of modelling
- Open Modelling Initiatives
  - Access to model components from many vendors via systems such as OASIS
  - Continued development of customised models reflecting Insured/Reinsureds Own View of Risk
- InsureTech & Big Data technologies
  - Sources of higher spatial and temporal resolution exposures
  - Better capture of event data to improve models

Q&A

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Closing

THANK YOU