Role of Catastrophe Modelling in Reinsurance

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Balatonvilagos, May 21, 2011

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Agenda

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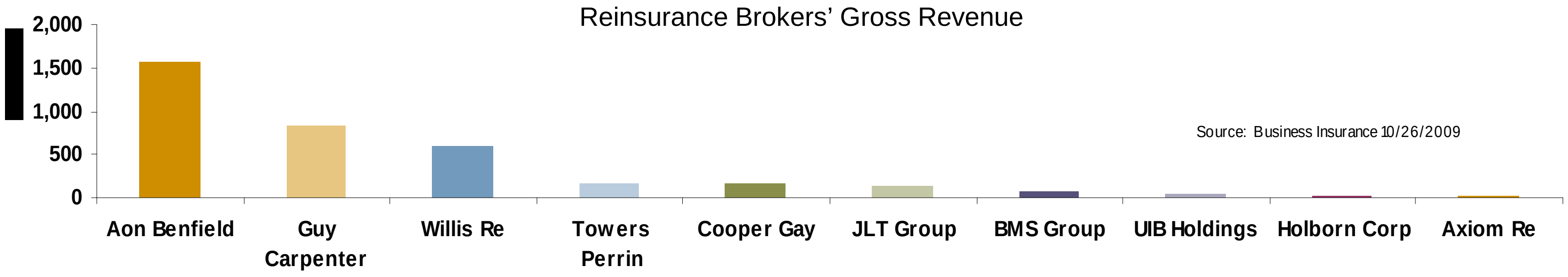
Aon Benfield

- Aon Benfield offers best-in-class client servicing capabilities with local presence in more than 50 countries around the world
- Aon Benfield is the world's largest reinsurance broker with over 150 Clients in CEE (globally 3,000)

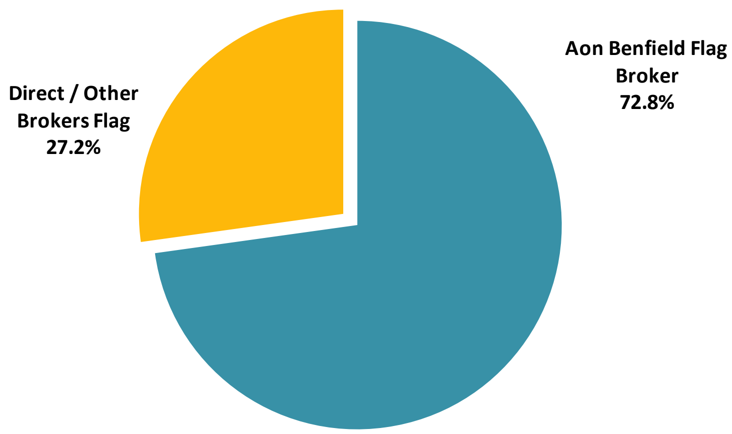


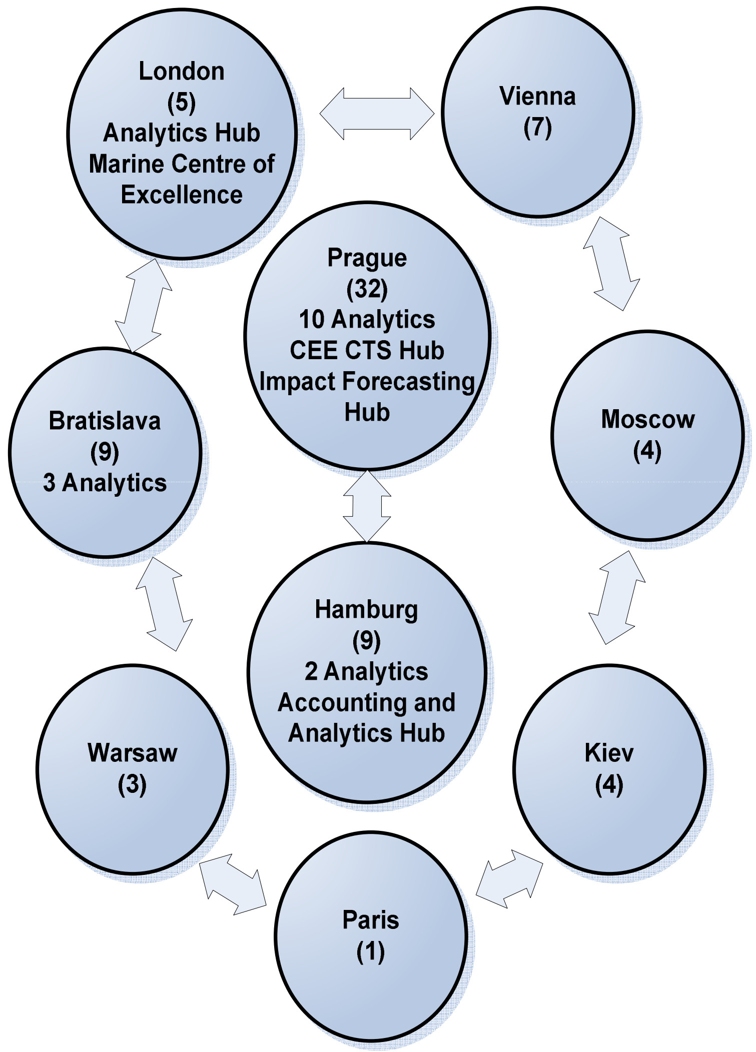
- Our size and reach allow us to access capacity in markets that are inaccessible to our competitors, to the benefit of our clients

Aon Benfield Austrian and CEE Team

- All part of ONE Austrian and CEE Team with over **70 staff dedicated to the region**
- CTS Hub in Prague to provide highest quality of claims and accounting service to CEE and Nordic customers
- Separate Hub in Hamburg covering German speaking clients
- **15+ locally based Analytics team members**
- Our culture encourages one team approach. We operate as single cohesive unit with no boundaries in order to achieve our customers' best interest.

Aon Benfield Cat XL Market share (based on premium)





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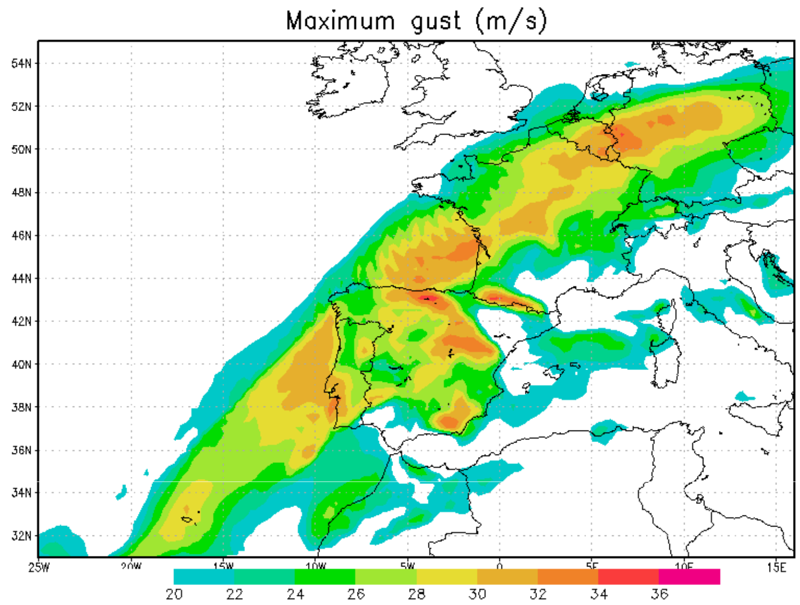
2. Natural Catastrophes

Windstorm

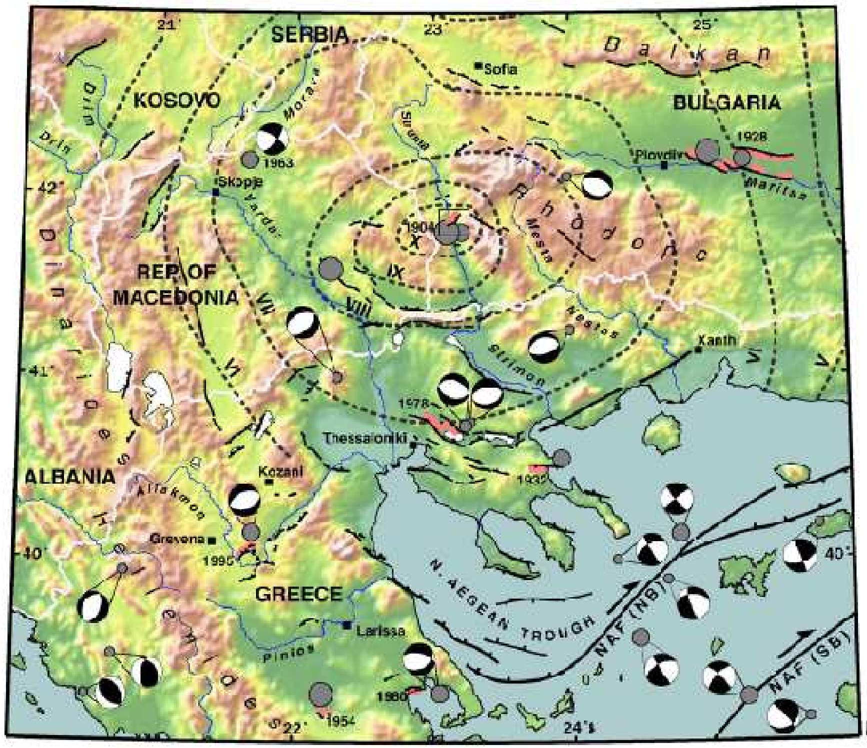
- **Typical features:**
  - Large territories affected
  - Low damage ratios, serious structural damage is rare (destruction of walls, failure of buildings)
  - Low number of casualties
  - Multi-country losses in Europe
- **Main windstorm territories** (RI point of view): Western European winter storms, US hurricanes.
- **US Hurricane season:** June – October
- **Western European Windstorm season:** October – March



Xynthia windstorm, February 2010

Earthquake

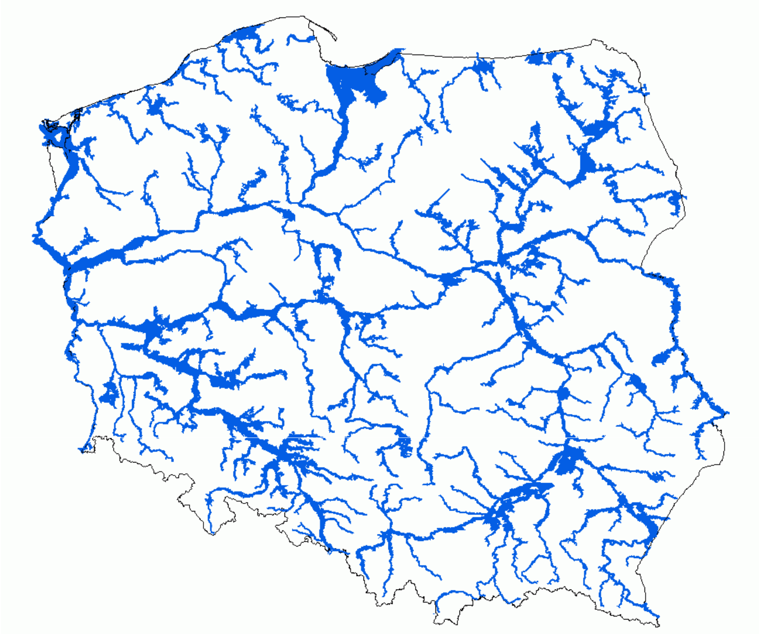
- **Typical features:**
  - Smaller territories affected
  - Usually only single country losses
  - Damaging earthquakes are less frequent than floods and windstorms. Typical – low frequency and high severity.
  - High damage ratios, serious structural damage (failure of walls, collapse of buildings)
  - Usually high number of casualties
- **Main earthquake territories** (RI point of view): **Japan, California**



4 April, 1904, SW Bulgaria. Shallow event, magnitude M = 7.8

Flood

- **Typical feature**
  - Flood propagates along river streams and cannot affect large areas continuously, like wind or earthquake
  - Lower damage ratios, serious structural damage is not common
  - Low number of casualties
  - Typical - multi-country losses in Europe
  - Loss prevention can be very effective – flood defences, early warning
- **Main Flood territories** (RI point of view): CEE, Western Europe, UK.



Floodable zones in Poland

3. Aon Benfield Catastrophe Analytics

Why to Use Cat Models?

- **Prerequisite:** Insurance company needs to buy reinsurance cover to protect its **Property** portfolio
- **Question 1:** How much cover should be purchased? Factors:
  - Presence of different Natural Hazards in the particular country
  - Loss potential (250 years loss) for a particular Natural Hazard
  - Presence of recent losses
  - Regulatory requirements
- **Question 2:** For what price is the cover purchased? Factors:
  - Presence of recent losses
  - Current reinsurers' risk appetite (market situation)
  - Brokers ability to place the business

- **Role of catastrophe modelling**
- Indicate to insurers what their potential losses are ➔ **reduce uncertainty**
- Support brokers to get better price for reinsurance
- Reinsurers knows what risks they are taking on board
- Estimation of possible losses ➔ all parties benefit
- Modelled 1in250 years loss is often used as a standard for capacity purchase

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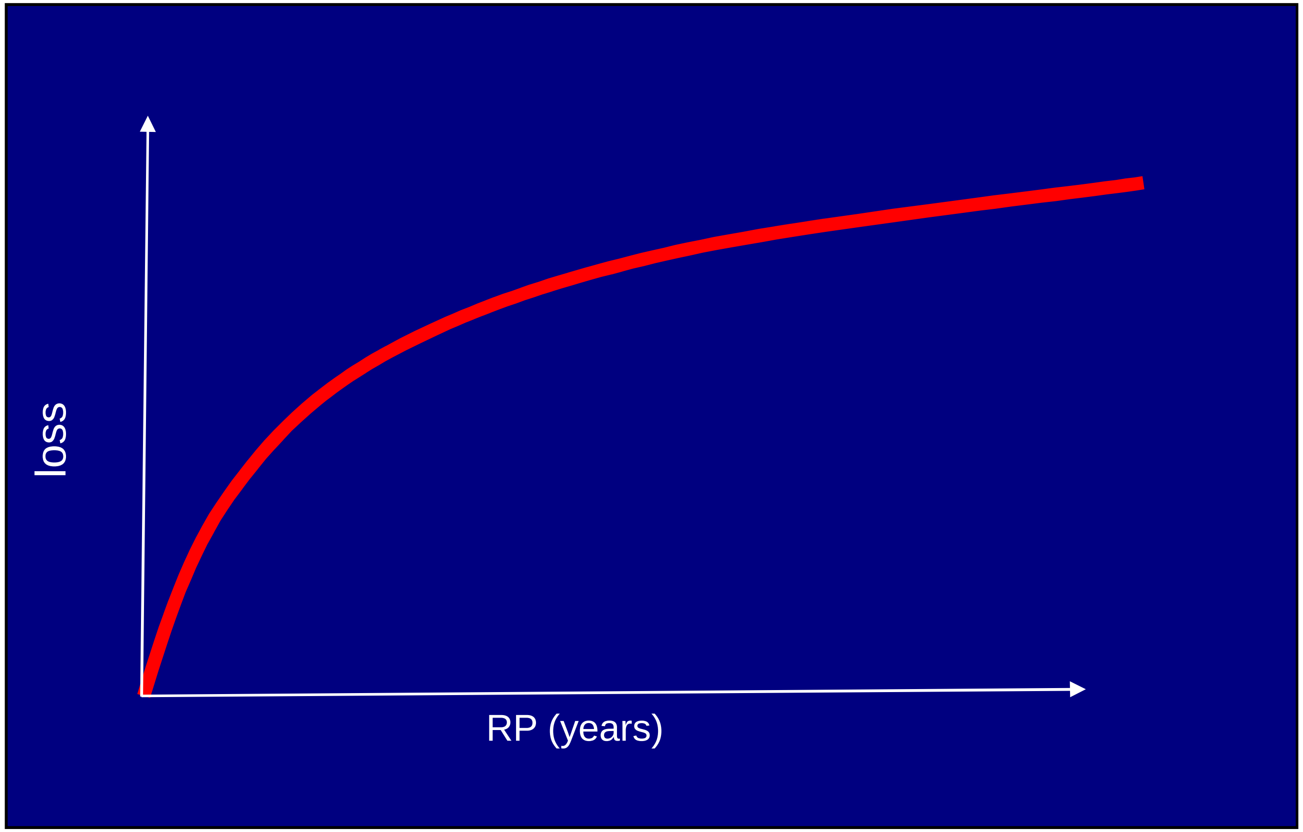
Cat Model Output

- Loss exceedance probability curve
- Loss of amount X (1bn) could be expected to happen in average once in Y years (250).



Aon Benfield Analytics Practice Groups

Catastrophe Management	Actuarial	Rating Agency Advisory	Risk and Capital Strategy	Market Analysis	Products and Solutions
In-House Multi-Model Risk Assessment	Experience & Exposure Rating	Rating Agency Implications of Reinsurance	Risk Tolerance and Risk Appetite	MarketReView®	Impact Forecasting Catastrophe Models
Risk Transfer Structuring	Reinsurance as Capital	BCAR/SPCAR Pro Formas	Enterprise Risk Management	Market News & Updates	ImpactOn Demand™ Risk Intelligence
Catastrophe Actuarial and Cat Score®	Reinsurance & Portfolio Optimization	Communicating with Rating Agencies	Economic Capital Adequacy and Allocation	Market & Group Profiles	ReMetrica® Risk and Capital Modeling
Academic & Industry Collaboration	Insurance Risk Study	Criteria Changes	Solvency II	Reports	Annuity Solutions Group PathWise℠

Aon Benfield Analytics – Impact Forecasting

Products and Solutions

- Impact Forecasting Catastrophe Models
- ImpactOn Demand™ Risk Intelligence
- ReMetrica® Risk and Capital Modeling
- Annuity Solutions Group PathWise™

- **Impact Forecasting Global Team**
  - One team, sharing of Software, Methodology and Resources
  - Together approx. 45 people with various backgrounds (US, Europe, Asia)
  - In Europe (15 people): London, Prague and Hamburg
  - Important milestone – Aon Benfield merger – sharing know how and external consultants

- **Cat Models Development**
  - Most exposed and most important areas
  - Non-modelled perils and territories
  - Focus on Pan European coverage
  - Custom solutions e.g. vulnerability curves

- **Advantages of IF models**
  - Recognized by clients, reinsurers and regulators
  - Solvency 2 compliant models
  - Opened and fully documented

Aon Benfield Analytics – Catastrophe Management

Catastrophe Management

- In-House Multi-Model Risk Assessment
- Risk Transfer Structuring
- Cat Score®
- Catastrophe Actuarial

Catastrophe Management

- Multi-model capability: AIR, RMS, EQECAT, Impact Forecasting
- Wide ranging expertise: engineers, seismologists, meteorologists, geophysicists, GIS helping to understand and evaluate models
- Determining strengths and weaknesses of "black box" catastrophe models
- Identifying drivers of PML and understanding non-modelled loss drivers
- Improving data quality, a key driver for reinsurance load and capacity
- Design and evaluation of reinsurance programmes in conjunction with Actuarial/ERM and broking teams
  - Using ReMetrica (incorporating CatRAM)
- Benchmark pricing based on market data
- Client proposition supported by a range of tools including GeoMetrica, Impact on Demand and DPO

Catastrophe insight beyond models

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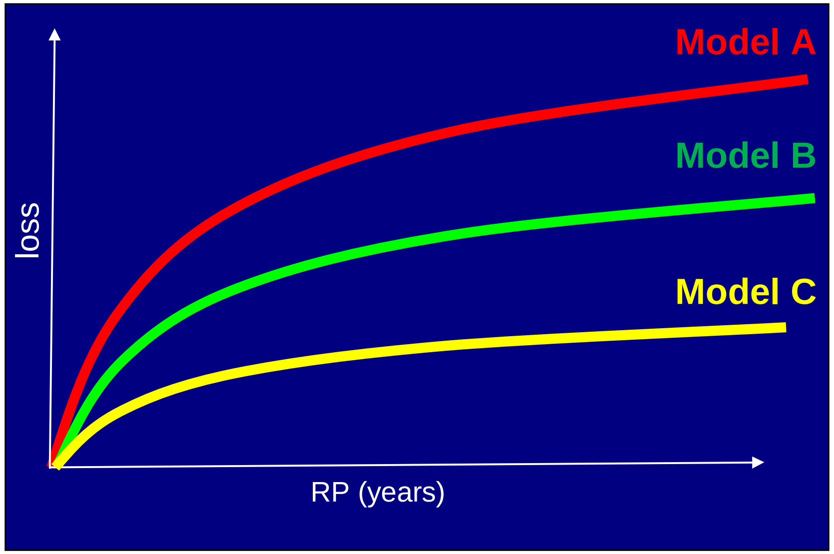
Benefits of Model Evaluation

- Opening the "black box"

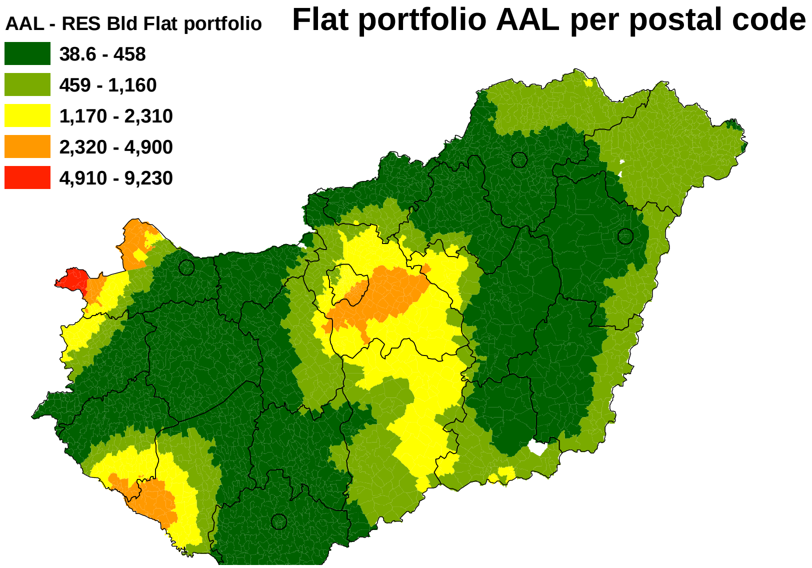
- **Aim to**
  - Understand the areas driving loss difference
  - Obtain a considered view of the strongest model for each territory and peril
  - Establish reliability of loss estimation against previous events

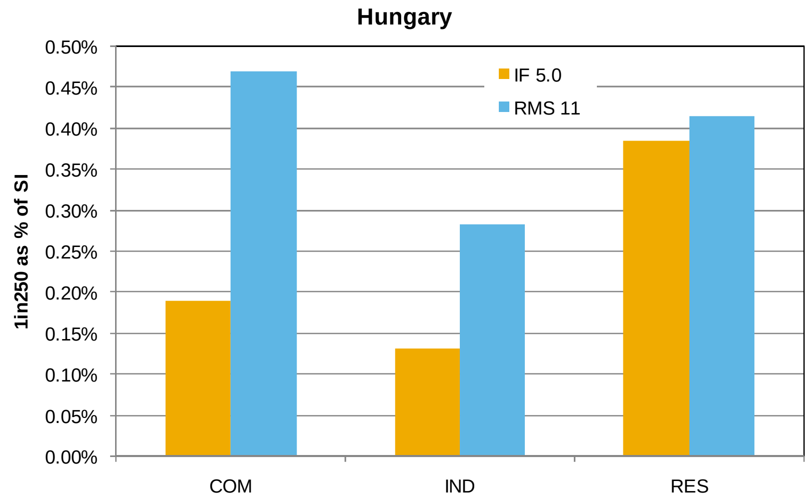
- **Two strands to evaluation approach**
  - High-level model / territory comparison using
    - "Flat" or synthetic portfolios
    - Industry exposure
  - Bespoke evaluation using client loss data for model validation

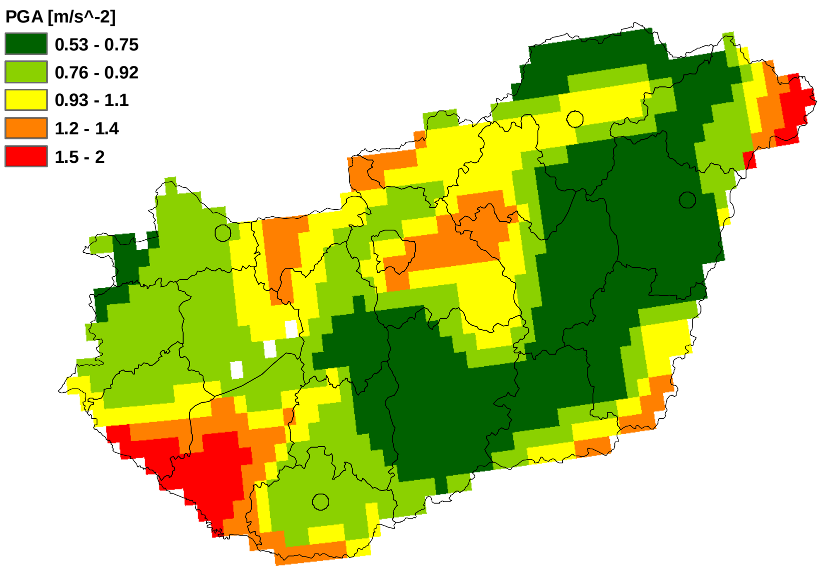
- **Evaluation is limited by data available**
  - E.g. Hazard parameters not produced by all models, so use AAL
  - Cannot always separate vulnerability / hazard impacts



RMS Quake Hungary Understanding Vulnerability and Hazard is Important







GSHAP Hazard map, 475 y return period

- In RMS Hazard in the area N and NW of Budapest seems to be underestimated, even if this is the most active zone in Hungary (M ~ 6.2 in 1763)
- Commercial LOB gives higher losses compared to residential, which is in contradiction to the loss experience

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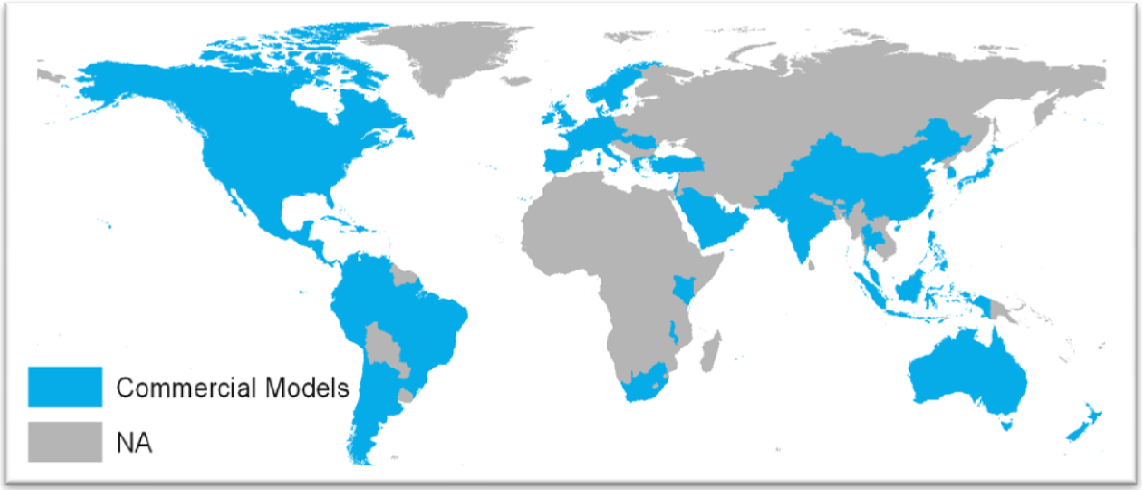
Third Party Vendor Models

- Made by modelling companies as their main source of profit
- 3 main companies:
  - **RMS** (Risk Management Solutions) - www.rms.com
  - **AIR** (Applied Insurance Research) - www.air-worldwide.com
  - **EQECAT** - www.eqecat.com - **Hungary Quake and Wind**



- **2011 vendor models updates:**
  - **AIR wind** (July 2011): Poland, Czech Republic, Baltic countries
  - **AIR quake** (July 2011): Romania, Bulgaria, **Hungary**, Austria, Slovenia, Slovakia, Czech Republic, Poland
  - **RMS wind** (July 2011): Poland, Czech Republic, Slovakia
  - **RMS quake** (March 2011): Romania, Bulgaria, **Hungary**, Slovenia

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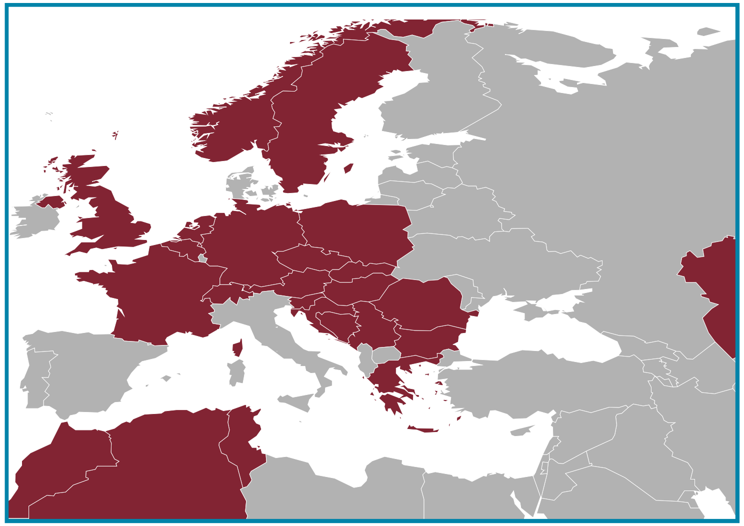
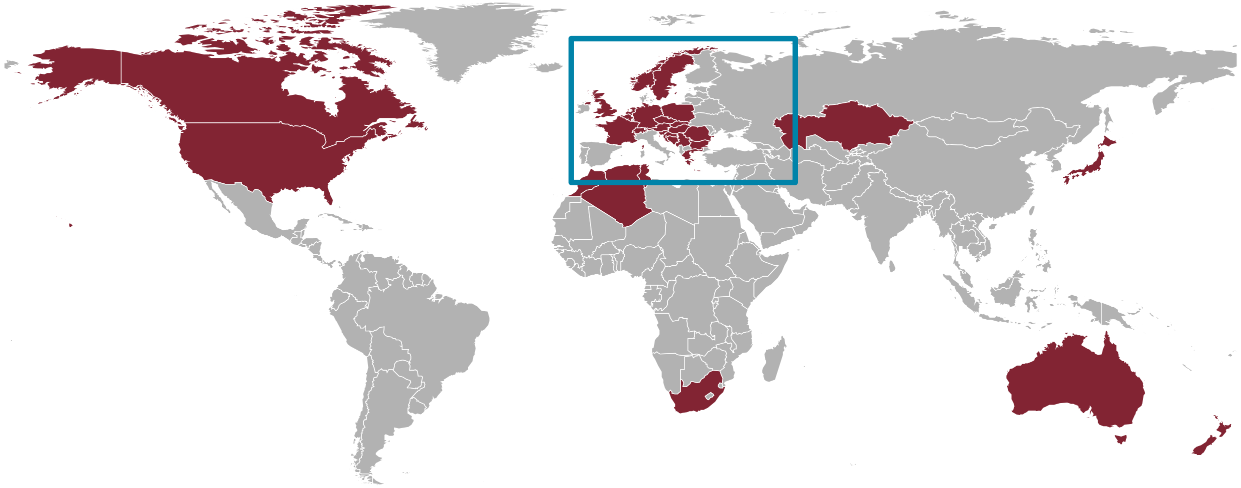
Aon Benfield Impact Forecasting Models

- **Modelled perils:**
  - Earthquake
  - River flood
  - Windstorm & Hail
  - Storm surge
  - Brushfire
  - Terrorism





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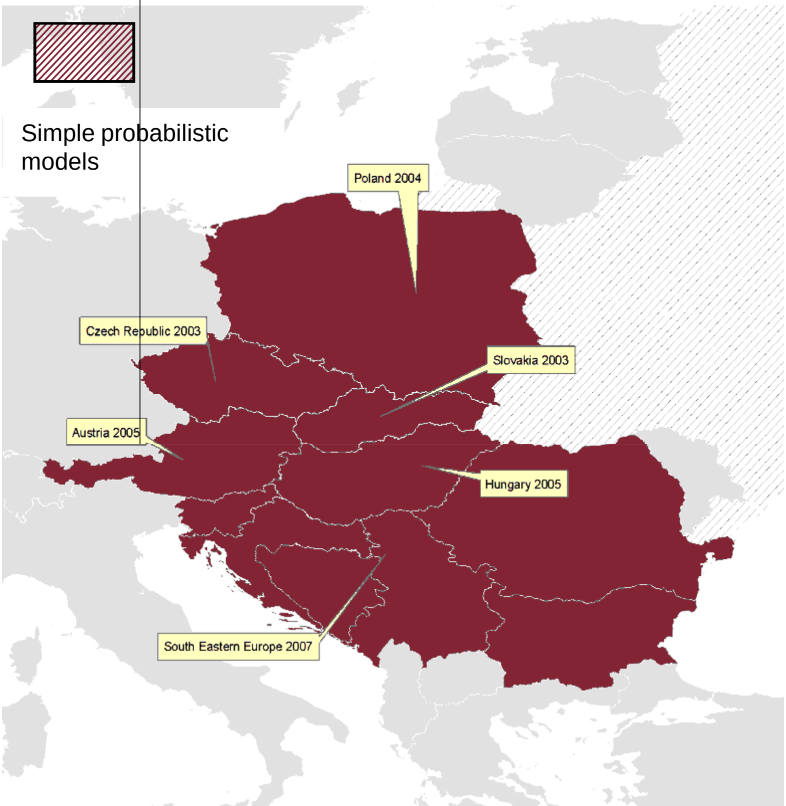
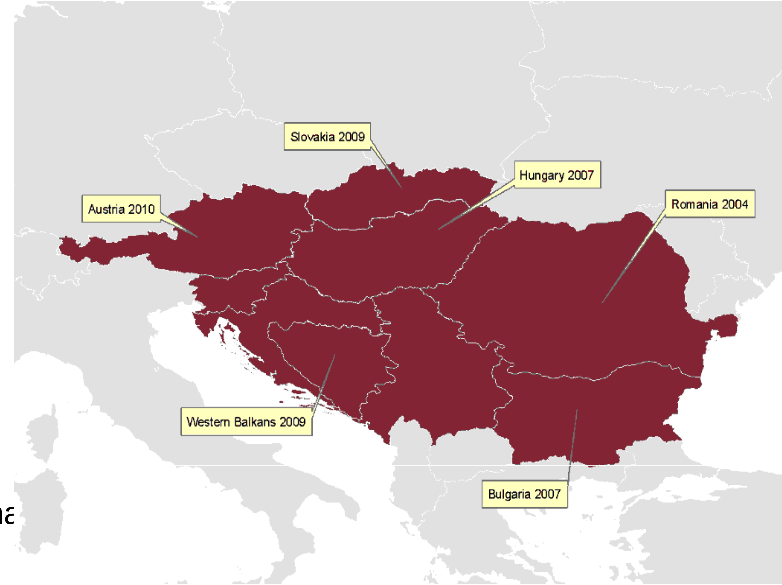
Impact Forecasting Flood Modelling in CEE

- IF Flood model history:
  - **Czech Republic → 2002, 2003** (update in 2009)
  - **Slovakia → 2003**
  - **Poland → 2004** (update in 2009)
  - **Hungary → 2005** (update in 2009)
  - **Austria → 2005** (update in 2010)
  - **South Eastern Europe → 2007**
  - **Russia & Ukraine & Belarus → 2008**
- First flood risk assessment modelling suite for the CEE
- Comprehensive claims database from 2002 Flood means the **vulnerability component is based on real losses**
- Models were tested on real events (1997, 2002, 2006, 2010)
- Regularly updated and detailed information on flood defences
- Detailed **DTMs** implemented (not DEMs!)
  - DTM – pure terrain elevation; DEM – top of the houses or vegetation cover
- **External support from local universities and hydro-meteorological institutes:**
  - *Charles University in Prague*
  - *University of Warsaw*
  - *Slovak University of Technology*
  - *Hungarian Water Research Centre (VITUKI)*
  - *EDAC Weimar*



Impact Forecasting Quake Modelling in CEE

- IF Quake model history:
  - **Romania → 2004** (update in 2006 and 2009)
  - **Bulgaria → 2007** (update in 2008)
  - <u>**Hungary → 2007** (update in 2008)</u>
  - **Kazakhstan → 2007** (update in 2008)
  - **Slovakia → 2009**
  - **Western Balkans → 2009**
  - **Austria → 2010**
- In most of the CEE countries, IF Quake is the only available tool for earthquake risk assessment
- Transparent and credible models well received by reinsurers
- Support from leading local experts as well as international scientific organizations:
  - *Bulgarian Academy of Sciences*
  - *Technical University of Bucharest*
  - *National Seismic Survey of Serbia*
  - *University of Skopje*
  - *GFZ Helmholtz Centre Potsdam*
  - *EDAC Weimar*



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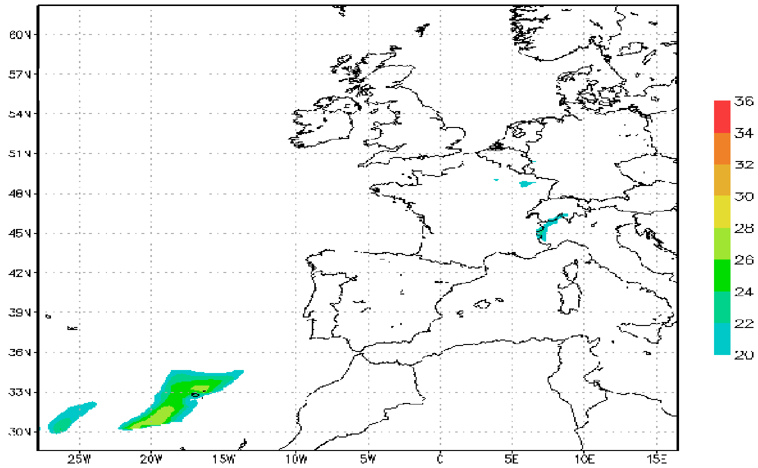
Impact Forecasting Wind Modelling in CEE

- Pan European windstorm model in progress
- First probabilistic model with continuous coverage across CEE countries
- Compared to commonly available models, summer storm and hail will be included as well, as CEE is not so much winter storm driven as Western Europe
- Main external consultant University of Cologne
- 3-year cooperation project planned with 2 major components:
  - Winter storms modelling
  - Summer storms and hailstorm modelling



IF in house simulation of Xynthia footprint

In-house footprint simulation with NWP (Numerical Weather Prediction) model

- Better understanding of the hazard
- Case studies possible, adding new events, validation…
- Dynamical analysis/forecast of meteorological fields in any resolution

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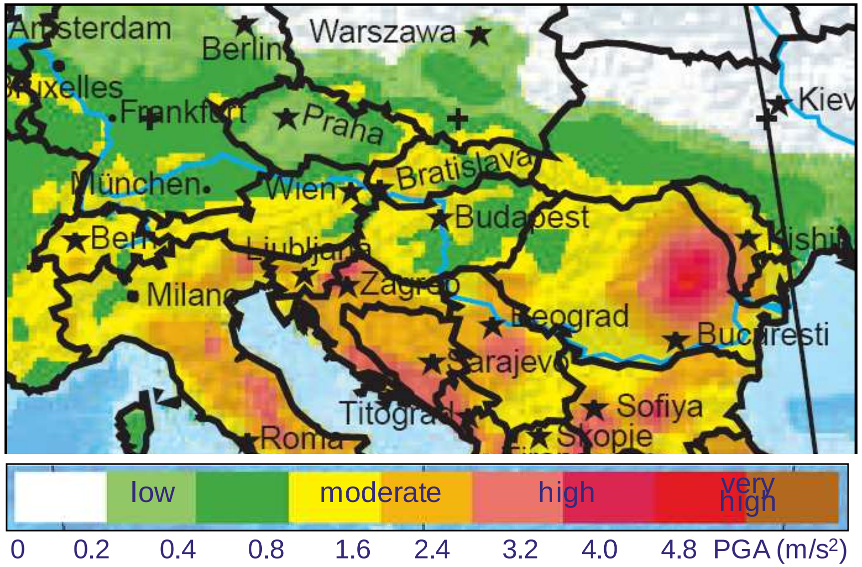
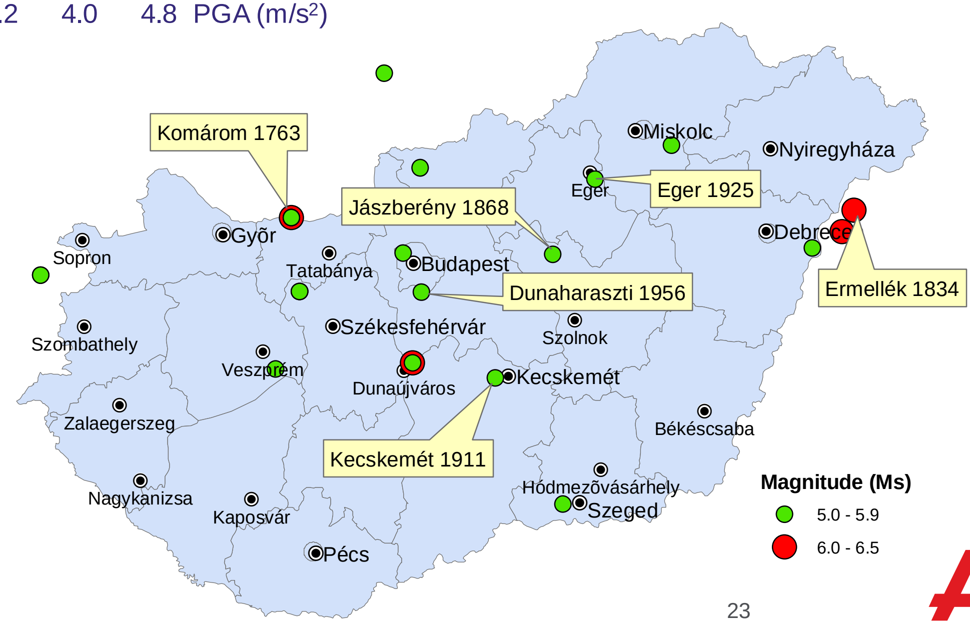
4. Aon Benfield IF Quake Model - Hungary

Seismic hazard in Hungary



Epicentre	Date	M	Io
Ermellék (Gálospetri)	15/10/1834	6.5	9.0
Komárom	28/06/1763	6.2	9.0
Dunaharaszti	12/01/1956	5.6	7.5
Jászberény	21/06/1868	5.3	7.5
Eger (Ostoros)	31/01/1925	5.0	7.5
Kecskemét	08/07/1911	5.6	7.0

Bus, Szeidovitz and Vaccari (2000)



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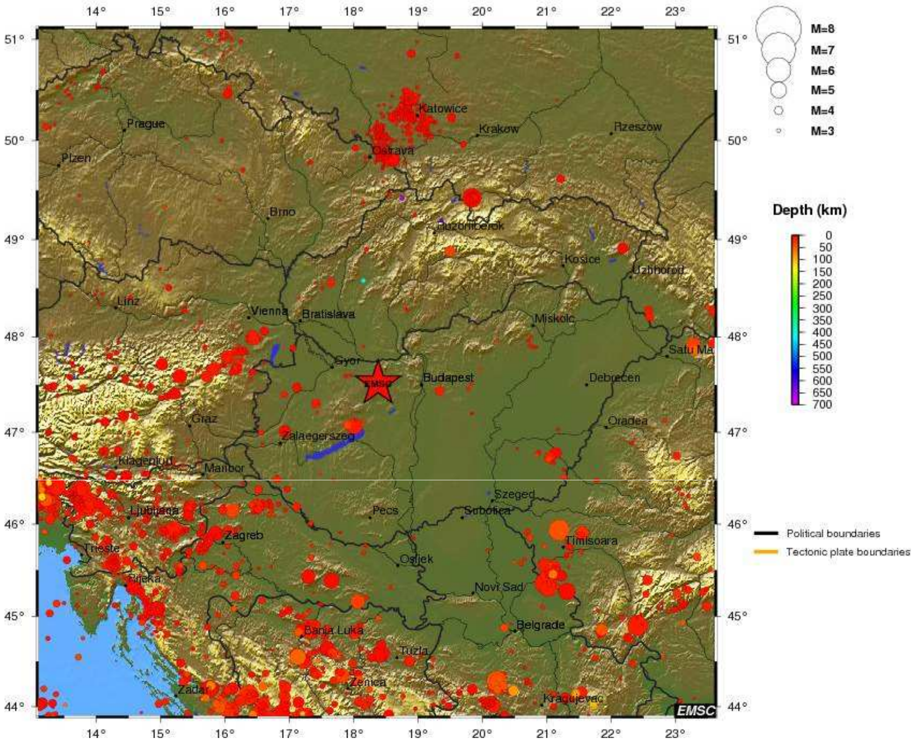
January 29, 2011 Earthquake in Northern Hungary



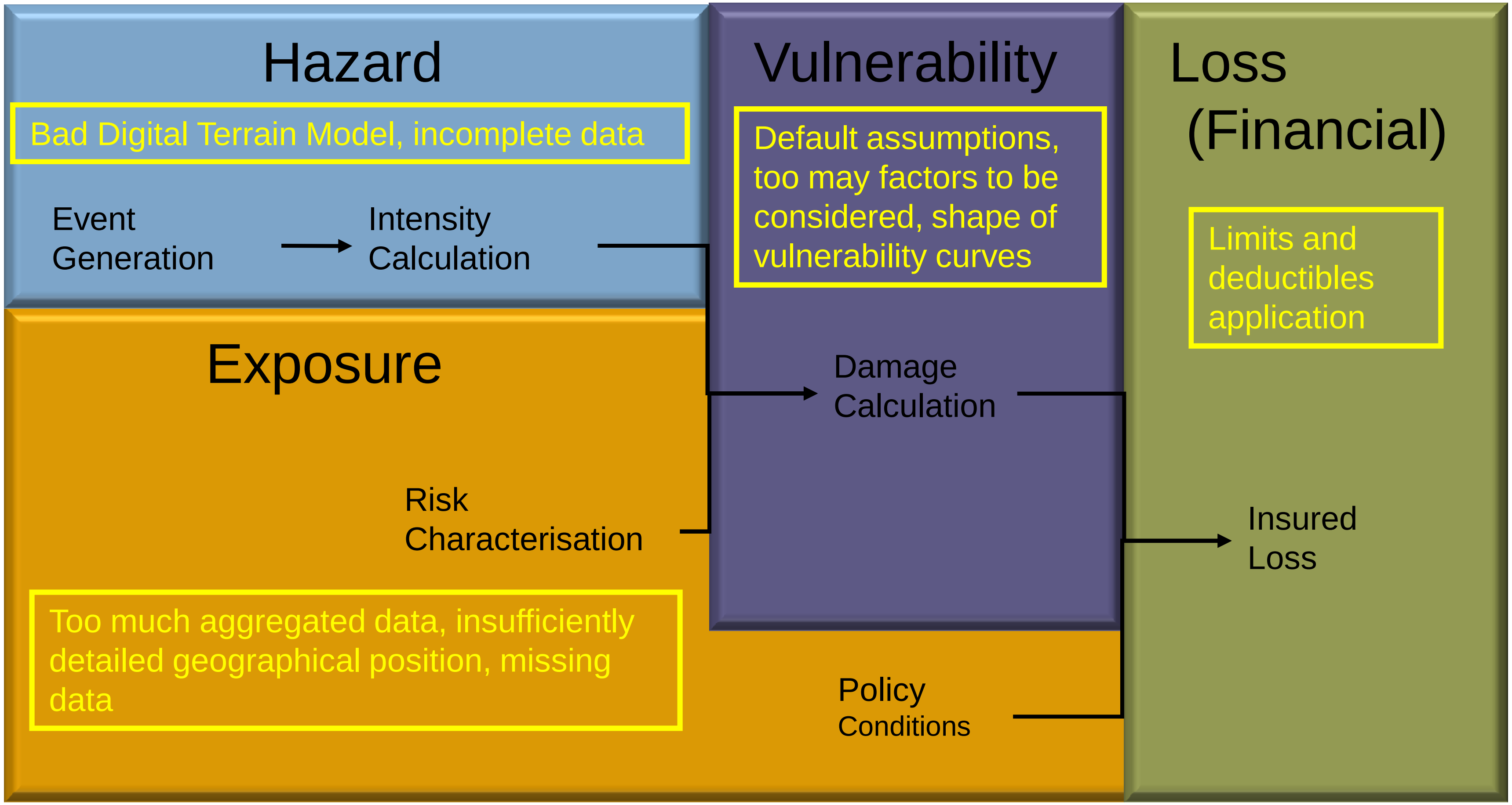
- January 29, 2011
- Magnitude Mw = 4.3 (USGS NEIC)
- 5 km SW of Tatabanya
- Felt in Budapest with no damage
- Depth ~ 5 km
- ~ 15,500 claims
- > HUF 1.5 bn insured loss
- Relatively high loss for rather weak earthquake
- However, the event was shallow and close to the inhabited areas

IF Quake Hungary Model

Country	HU, SK, RO, BG
Unique Features	Based on EU coordinated project, the only available earthquake model for Slovakia, for Hungaria Aon Benfield has prompted EQECAT to change its model
First Developed	2007 (semi probabilistic), 2008 (probabilistic), coverage extended to Slovakia in 2009
Model Basis	Impact Forecasting ELEMENTS 5.0, part of cross country model covering SK, HU, RO & BG
Academic Support	Based on EU coordinated project: “Quantitative Seismic Zoning of the Circum Pannonian Basin”
Attenuation Function	Based on Shebalin and Leydecker (1998) for Central and South-Eastern Europe
Vulnerability Function	EMS-98 based

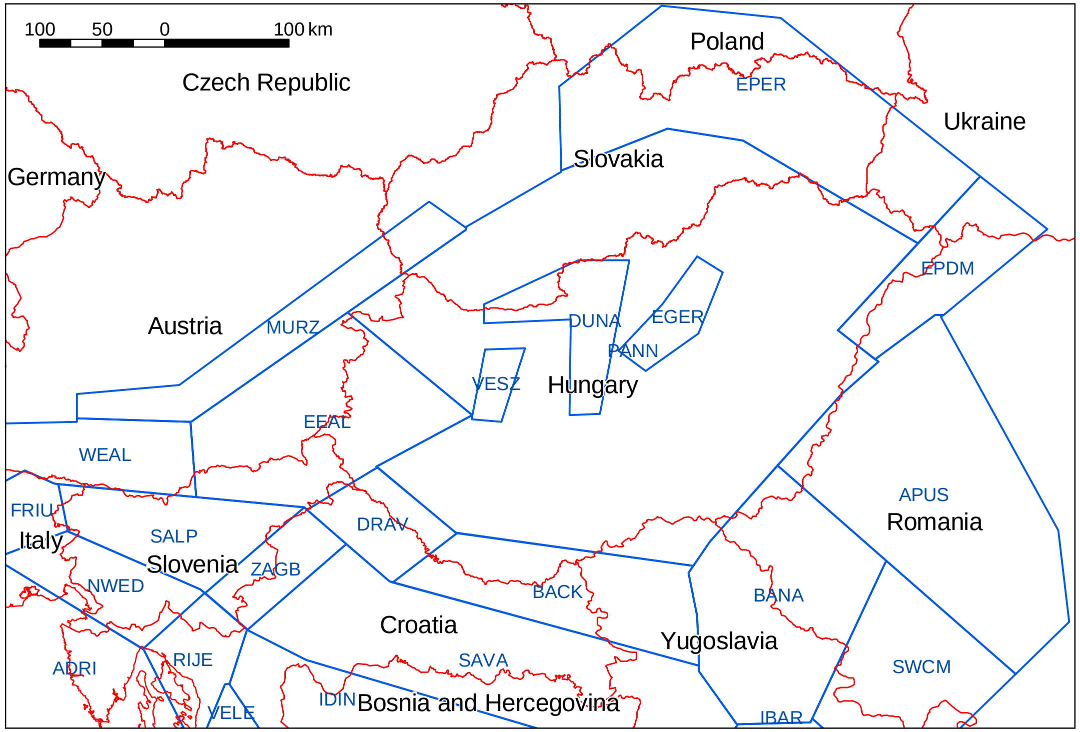
Komárom 1763

Cat Model Structure



Seismic source zones

11 seismic source zones capable of producing a loss in Hungary



Source zones specifics (always based on historical information)

- *Maximum magnitude*
- *Earthquakes recurrence rates*
- *Hypocentral depth*
- *Spatial distribution of earthquakes*

Stochastic catalogue

Time period for simulation

- *20,000 years*

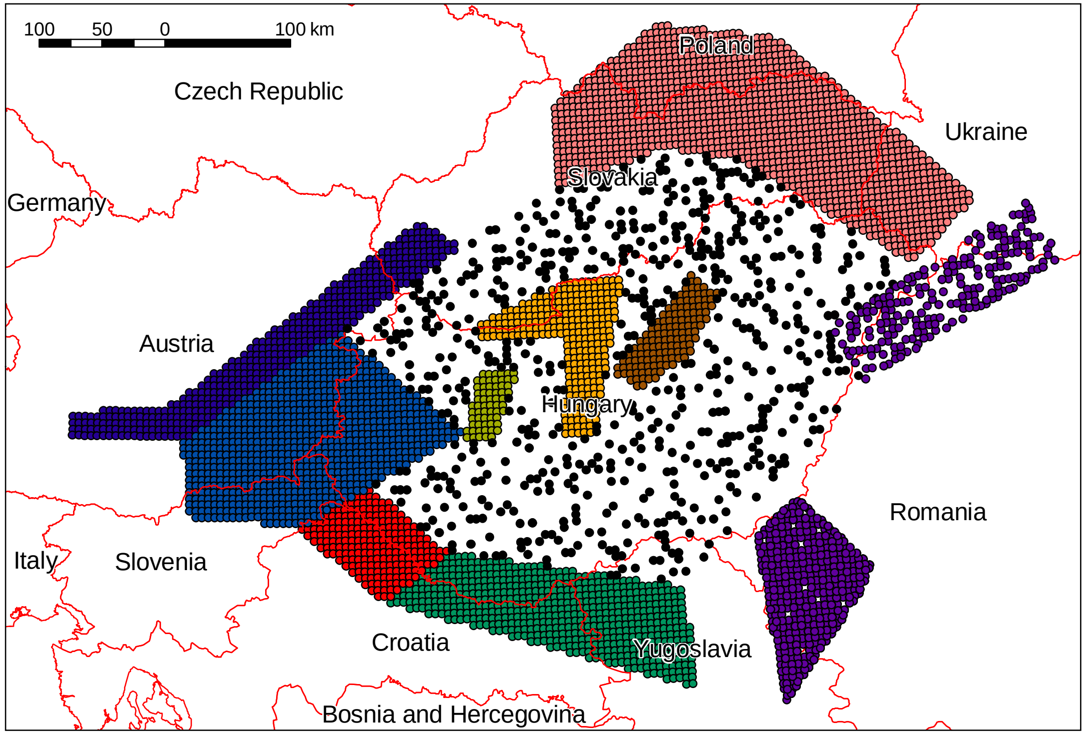
Number of events

- *> 9,000*

Minimum magnitude

- $M_{min} = 4.5$

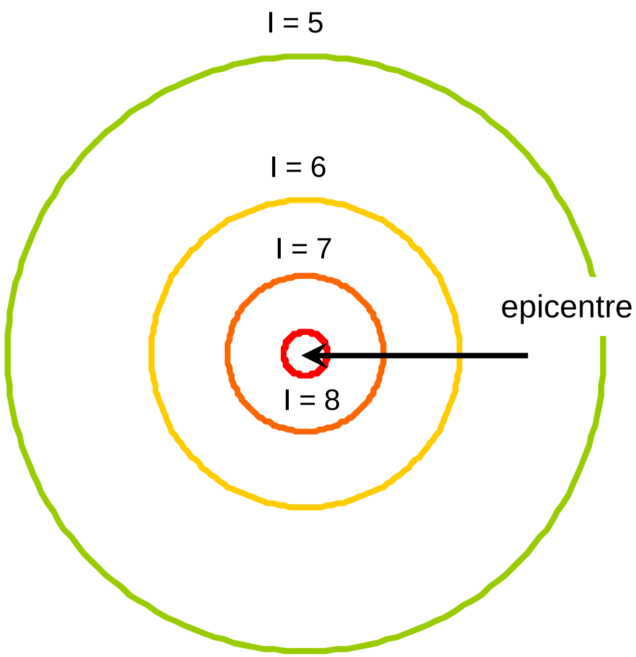
Magnitude step = 0.1



- Maximum magnitude = M_{max} in historical catalogue +0.5.
- Random distribution of events within each source zone.

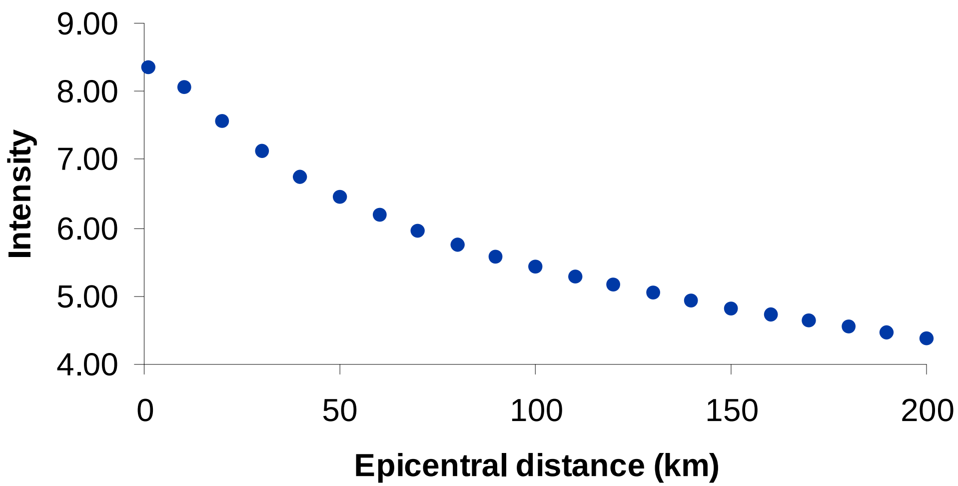
Intensity attenuation function

What is the maximum distance beyond which there are no losses?



- Each event generates a ground motion quantified by the intensity *I*
- Decrease of intensity with the distance from earthquake's epicentre is quantified by attenuation function

*Shebalin (1998): $I = aM - b\log\sqrt{(D^2 + H^2)} + c$



*Shebalin, N. V., 1998: Earthquake catalogue for Central and Southeastern Europe 342 BC – 1990 AD

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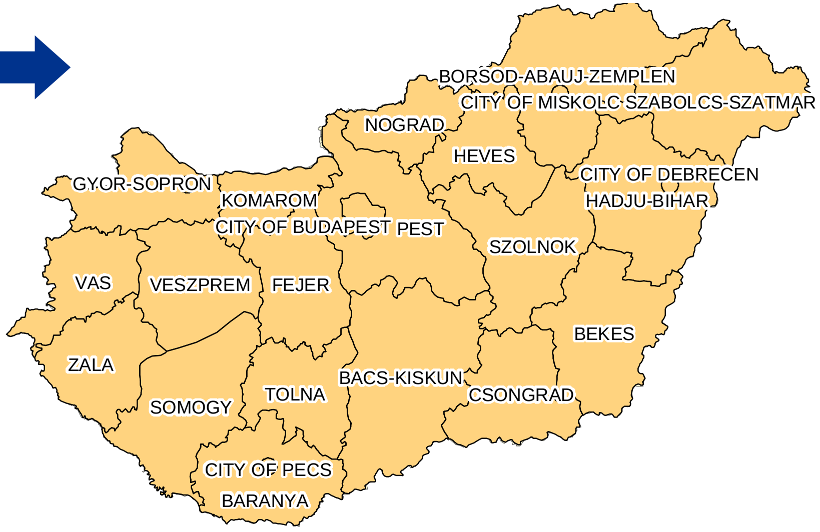
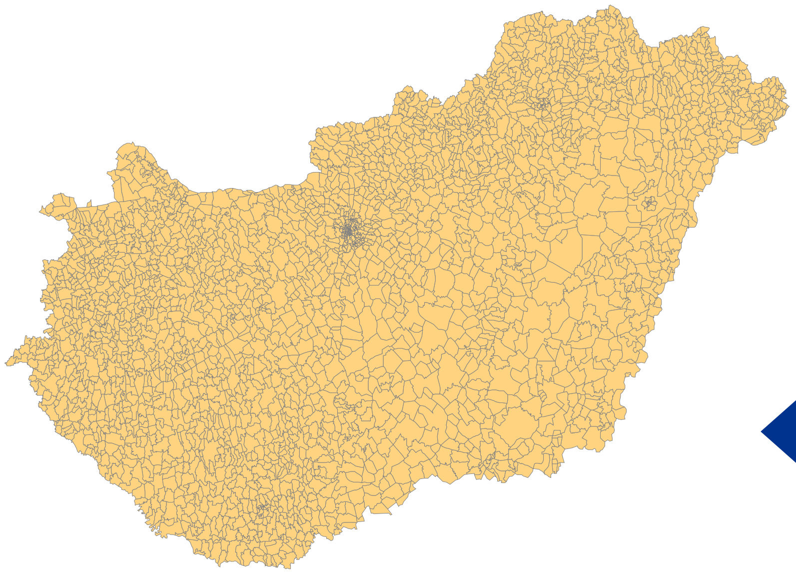
Importance of Exposure Details

- **CRESTA** level - **C**atastrophe **R**isk **E**valuating and **S**tandardizing **T**arget **A**ccumulations
- **24** CRESTA zones in Hungary
  - Not suitable for modelling without further spatial redistribution





- 4 digit postcode geocoding level
  - Much more suitable for the earthquake loss modelling
  - More reliable results can be expected
- CRESTA aggregated data
  - Redistributed into postcodes based on population density or market info

Vulnerability component

Vulnerability classes according to EMS-98 scale

Building types: A, B, ...F

A: poorest building type

F: earthquake resistant design buildings

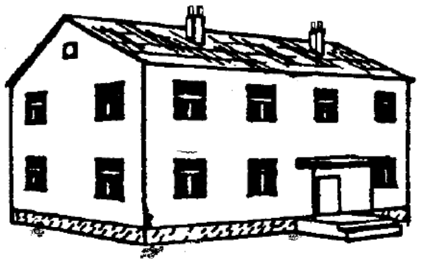
	TYPE OF STRUCTURE	VULNERABILITY CLASS A	B	C	D	E	F
MASOMRY	rubble stone, fieldstone	most likely					
MASOMRY	adobe(earthbrick)	most likely	probable				
MASOMRY	simple stone	exceptional	most likely				
MASOMRY	massive stone		probable	most likely	exceptional		
MASOMRY	unreinforced, with manufactured stone units	exceptional	most likely	exceptional			
MASOMRY	unreinforced, with RC floors		probable	most likely	exceptional		
MASOMRY	reinforced or confined			exceptional	most likely	probable	
REINFORCED CONCRETE (RC)	frame without earthquake-resistant design (ERD)	exceptional	probable	most likely	exceptional		
REINFORCED CONCRETE (RC)	frame with moderate level of ERD		exceptional	probable	most likely	probable	
REINFORCED CONCRETE (RC)	frame with high level of ERD			exceptional	probable	most likely	probable
REINFORCED CONCRETE (RC)	walls without ERD		exceptional	most likely	probable		
REINFORCED CONCRETE (RC)	walls with moderate level of ERD			exceptional	most likely	probable	
REINFORCED CONCRETE (RC)	walls with high level of ERD				exceptional	most likely	probable
STEEL	steel structures			exceptional	probable	most likely	probable
WOOD	timber structures		exceptional	probable	most likely	probable	

most likely vulnerability class (red) — probable range (yellow) — exceptional cases (light yellow)

Damage Grades

EMS scale based damage grades

Each building type suffer certain degree of damage (Damage grade) corresponding to the intensity of the ground shaking

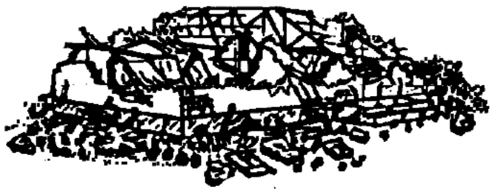


DG 1 – Negligible to slight damage: cracks in plaster

DG 2 – Moderate damage: cracks in walls, partial collapse of chimneys

DG 3 - Substantial to heavy damage: large cracks in most walls

DG 4 – Very heavy damage: serious failure of walls



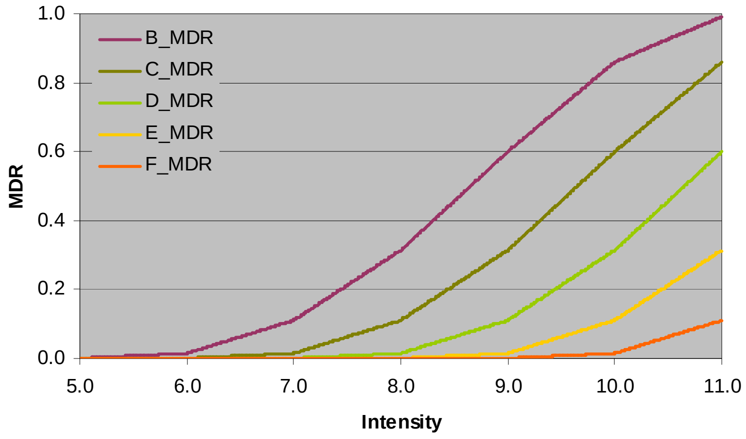
DG 5 - Destruction: total or near total collapse

Loss Calculations

Damage probability matrix (DPM)
↓
What is the percentage of buildings suffering different degree of damage for different intensities

Rebuilding ratio (RR)
↓
How much does it cost to repair the building. E.g for DG = 5, RR = 100%

Mean damage ratio (MDR)
↓
Sumproduct between % of affected buildings for each DG and rebuilding ratios corresponding to each DG. Quantifies the damage on buildings in % of SI



Example

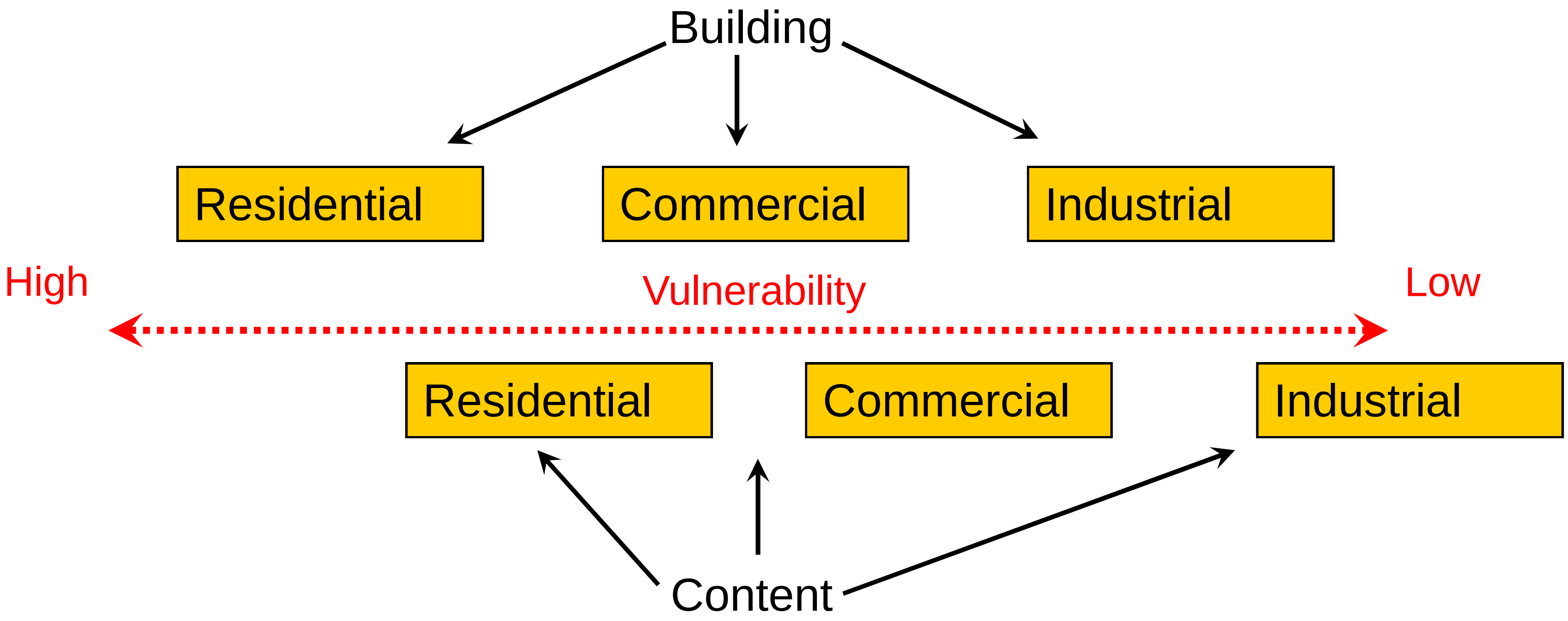
Intensity I = 8

Expected loss:

Class B … 31.3 % of the sum insured

Class D … 1.5 % of the sum insured

Vulnerability – What Drives the Loss



Residential portfolio ⇒ higher loss

Industrial portfolio ⇒ lower loss

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5. Catastrophe Modelling and Solvency II

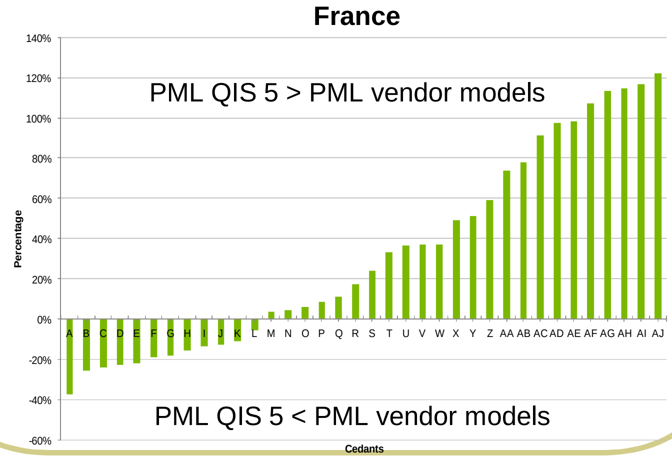
Standard Formula Nat Cat: Cat Models vs Scenario

Issues with Standard Formula

- Damage by Cresta zone is going back more than 15 years in time
  - Munich Re / Swiss Re approach prior to cat models?
  - Almost all clients have data more granular than Cresta
    - All commercial cat models have finer granularity
- Data quality is ignored
  - No impact for location granularity
  - No differentiation by occupancy
  - No impact for construction, age, height
  - Single damage function
    - No differentiation by buildings, contents, BI
  - No application of limits, excess, original deductibles

Comparison with Cat Models

- Potentially significant difference in output between Standard Formula approach and cat models
  - Scenario testing vs cat model by client
  - Negative percentage = cat model lower than scenario
  - For majority of clients the standard formula for natural cat is unacceptable



Our Recommendation:
Catastrophe Partial Internal Model

Flood

1. Calculate the gross 1/200 OEP per country

Provided per user

$$CAT^{Country}_{Flood} = Q^{Country}_{Flood} \sqrt{\sum AGG \times (F_{Zone} \times TIV_{Zone}) \times (F_{Zone} \times TIV_{Zone})}$$

Total Insured Value per Cresta

!! Fire, static Marine and aviation, Motor other

Vulnerability factor (Flood)

"Aggregation" Matrix (Flood)

1 in 200 OEP factor = 0.4% FL, 0.2% EQ

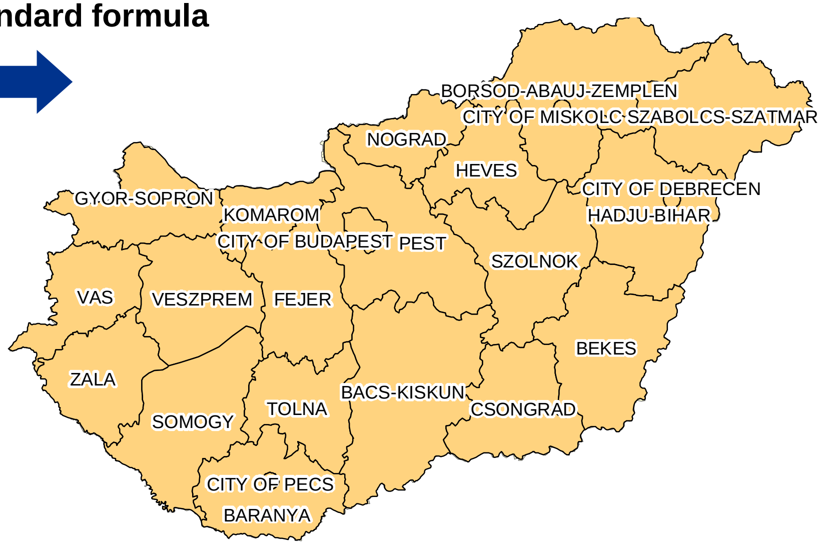
Parameters-non-life-catastrophe-risk_en.xls
FL_CRESTA_HU

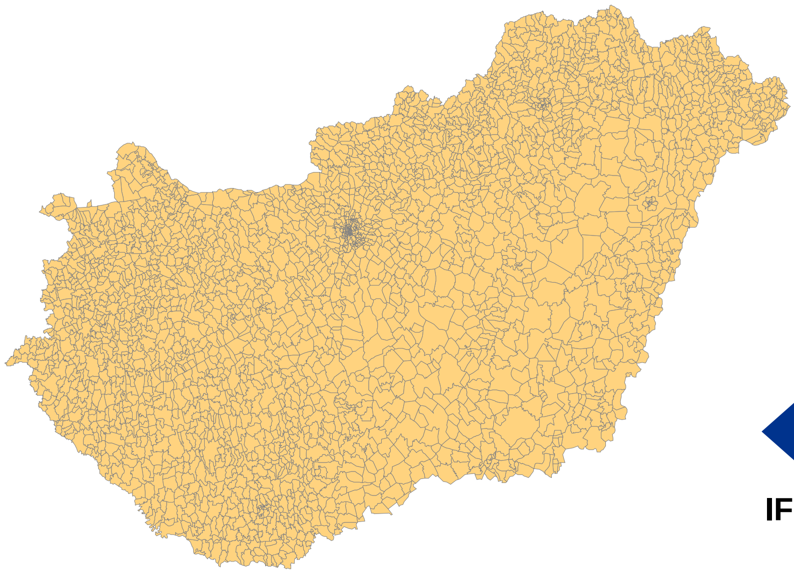
	A	B	C	D	E	F	G	H	I
1									
2			Market Factor						
3									
4			0.40%						
5									
6		Cresta Zone	Cresta Relativity		Aggregation Matrix				
7						1	2	3	4
8		City of Budapest	0.6		1	1.00	0.50	0.00	0.25
9		Gyor-Sopron	0.9		2	0.50	1.00	0.50	0.50
10		City of Gyor	13.7		3	0.00	0.50	1.00	1.00
11		Vas	0.6		4	0.25	0.50	1.00	1.00

Importance of Exposure Details

- **CRESTA** level - **C**atastrophe **R**isk **E**valuating and **S**tandardizing **T**arget **A**ccumulations
- **24** CRESTA zones in Hungary
  - Not suitable for modelling without further spatial redistribution

standard formula



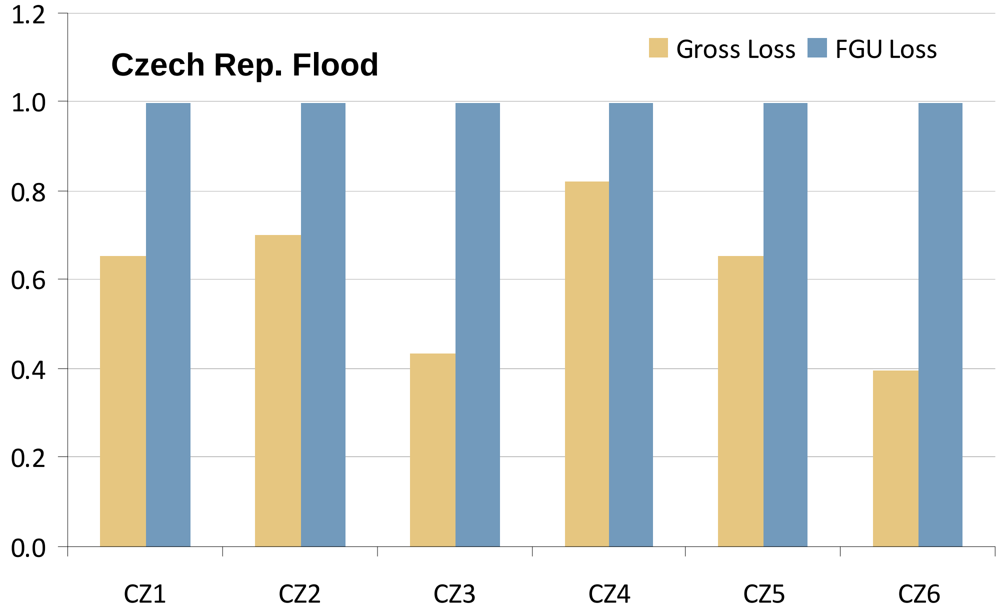


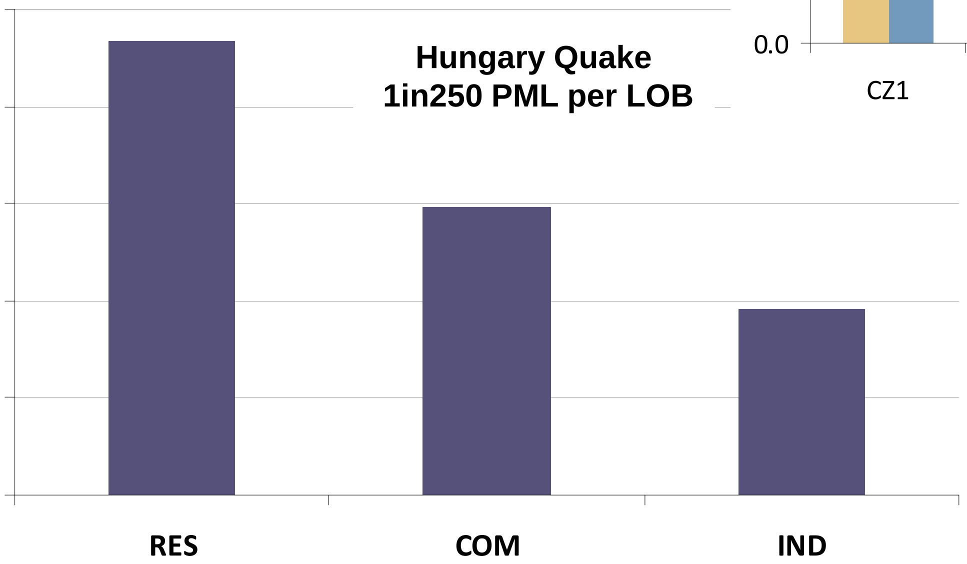
IF Cat model

- 4 digit postcode geocoding level
  - **> 3,000** 4-digit postal codes in Hungary
  - More reliable results can be expected

Importance of Policy Conditions and LOB Details

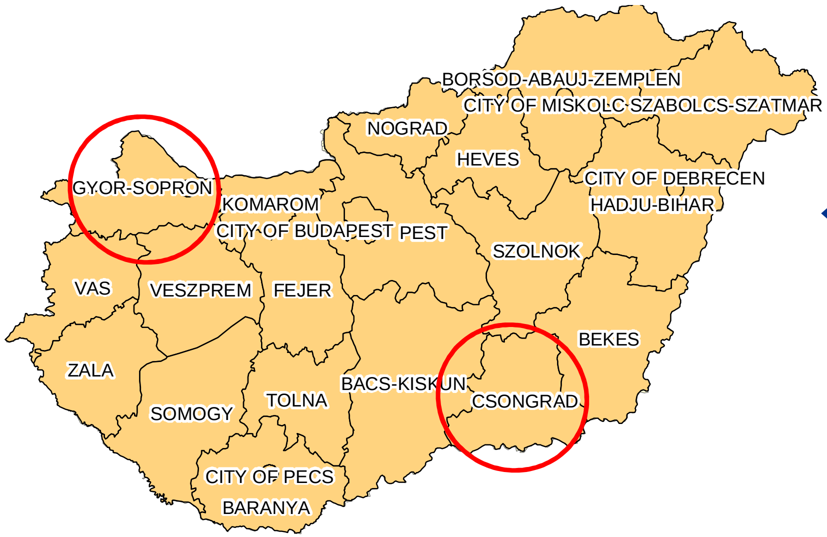
- Limits and deductibles can substantially reduce the loss
- But they cannot be applied when using the standard formula



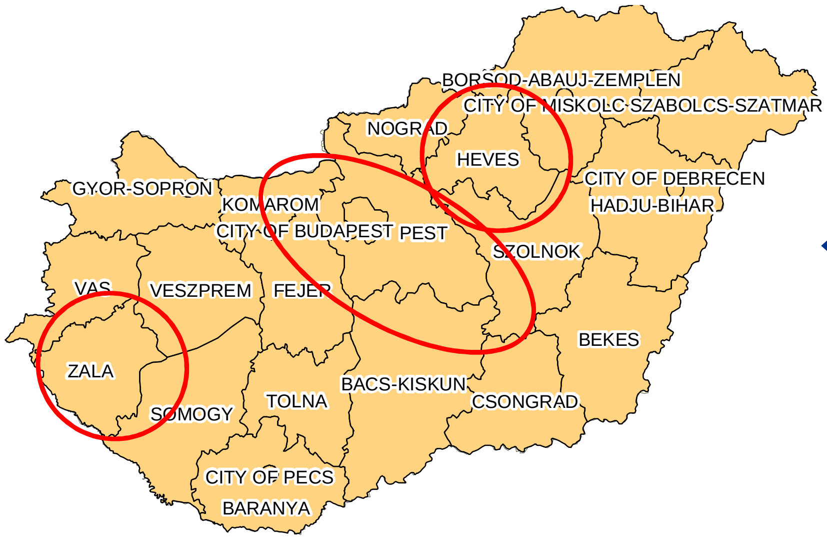


- Split per LOB can have a big effect on modelled loss
- However, there are no LOB specific damage functions assumed in standard formula

Standard Formula – What Drives the Risk in Hungary



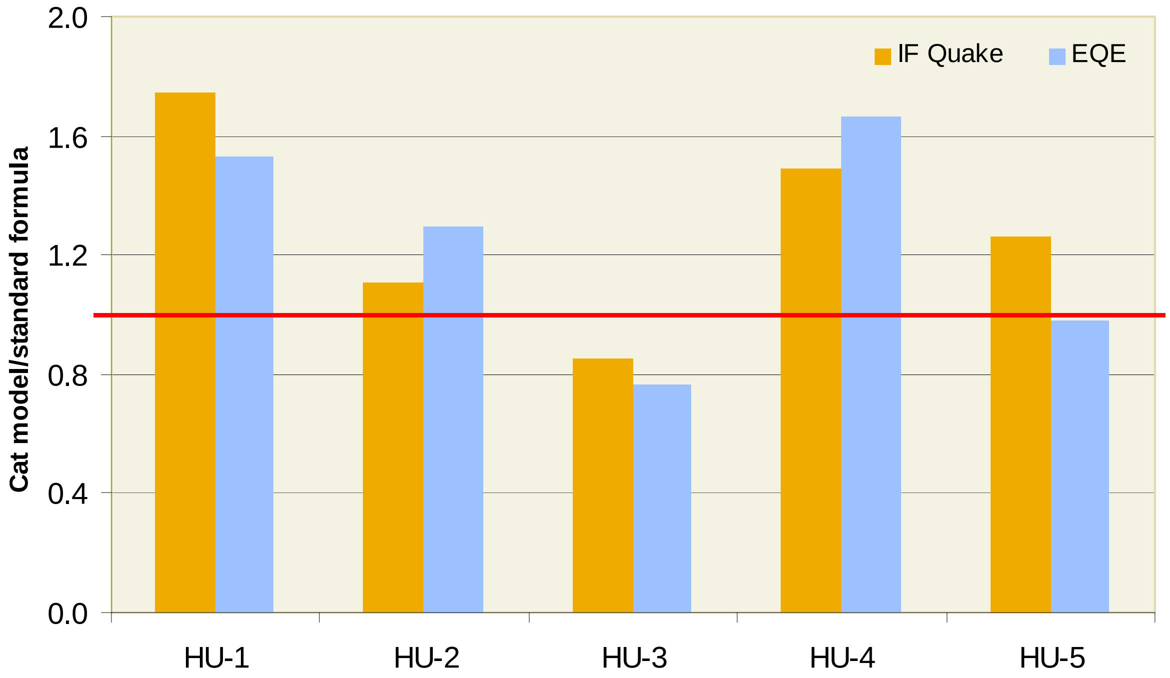
- Standard formula for flood – driven by CRESTA zones **City of Gyor, Csongrad**



- Standard formula for quake – driven by CRESTA zones **Budapest, Pest, Komarom, Heves, Zala**

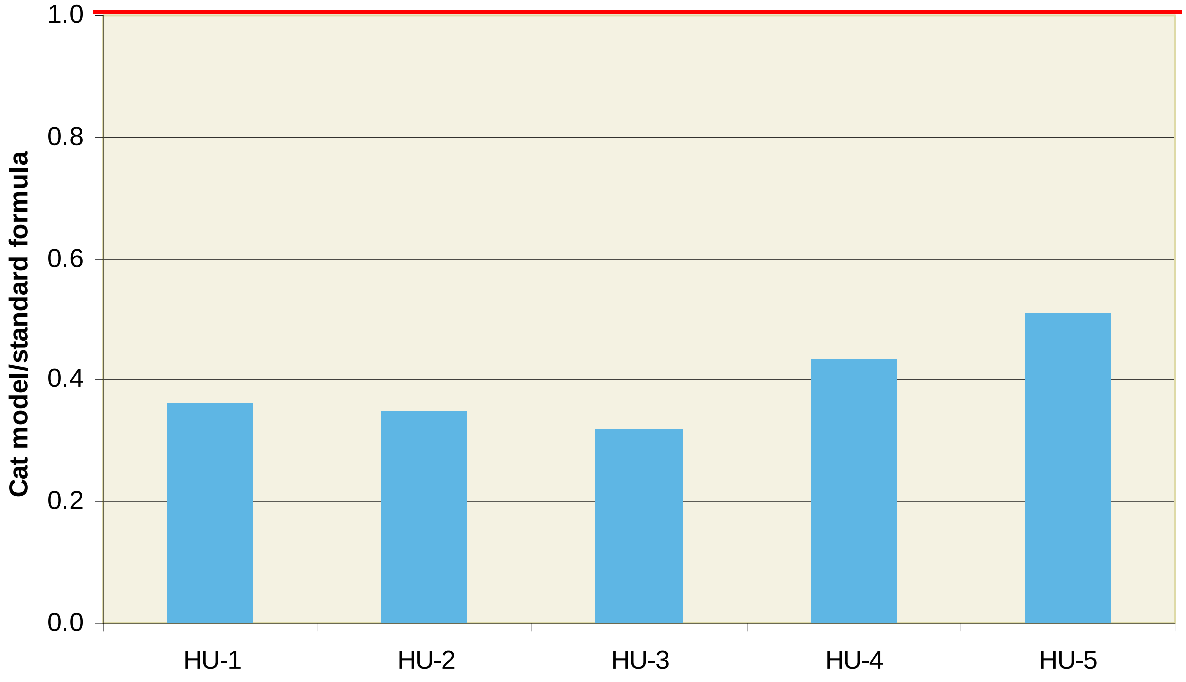
Standard Formula Results - Quake

- IF Quake: -15% lower - 75% higher
- EQE: -2% to + 70%
- Limits and deductibles cannot be excluded from the analysis
- Results based on standard formula parameters published on July 1st by CEIOPS – no further changes for QIS 5



Standard Formula Results Flood

- IF Flood: 49% - 68% lower
- Limits and deductibles cannot be excluded from the analysis
- Results based on standard formula parameters published on July 1st by CEIOPS – no further changes for QIS 5



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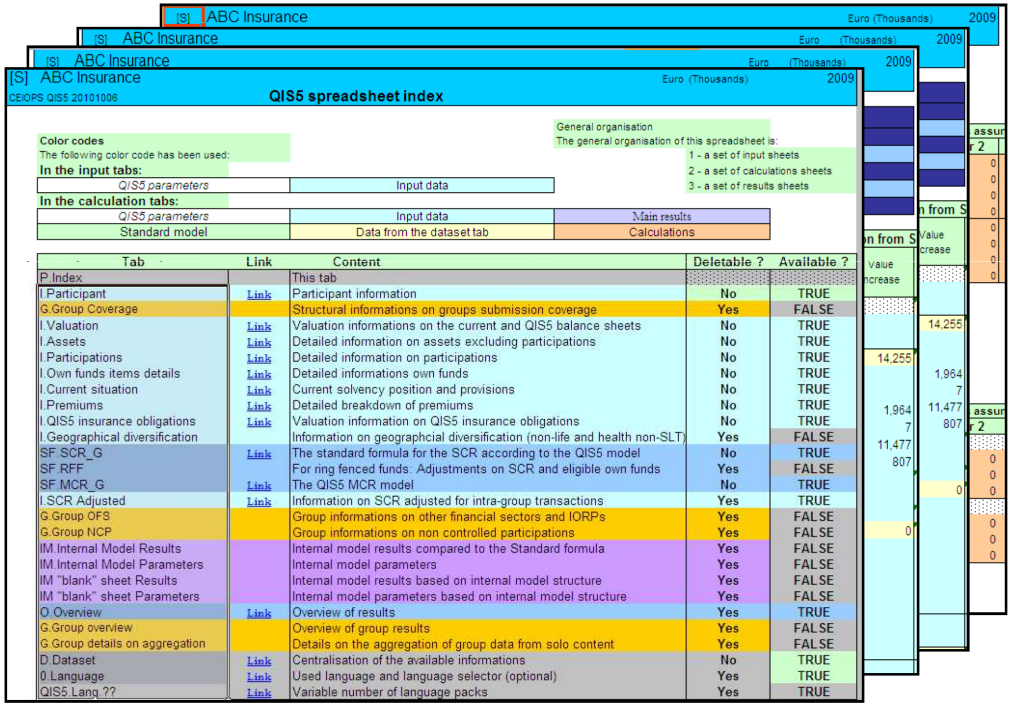
QIS 5 Results Analysis

- Calculates Solvency II capital charge under the Standard Formula
  - QIS 5 covers all aspects of balance sheet risks
    - Underwriting / Reserve
    - Cat
    - Investment
    - Credit
    - Operational
- Our Solvency II Dashboard provides a benchmark against the average European QIS 5 results
- **Provides key comparators for:**
  - **Non-life**
  - **Cat**
  - **Health**
  - **Life**
  - **Market**



[S] ABC Insurance — Euro (Thousands) 2009

CEIOPS QIS5 20101006 — **QIS5 spreadsheet index**

Color codes
The following color code has been used:
In the input tabs: QIS5 parameters | Input data
In the calculation tabs: QIS5 parameters | Input data | Main results
Standard model | Data from the dataset tab | Calculations

General organisation
The general organisation of this spreadsheet is:
1 - a set of input sheets
2 - a set of calculations sheets
3 - a set of results sheets

Tab	Link	Content	Deletable ?	Available ?
P.Index		This tab		
I.Participant	Link	Participant information	No	TRUE
G.Group Coverage		Structural informations on groups submission coverage	Yes	FALSE
I.Valuation	Link	Valuation informations on the current and QIS5 balance sheets	No	TRUE
I.Assets	Link	Detailed information on assets excluding participations	No	TRUE
I.Participations	Link	Detailed information on participations	No	TRUE
I.Own funds items details	Link	Detailed informations own funds	No	TRUE
I.Current situation	Link	Current solvency position and provisions	No	TRUE
I.Premiums	Link	Detailed breakdown of premiums	No	TRUE
I.QIS5 insurance obligations	Link	Valuation information on QIS5 insurance obligations	No	TRUE
I.Geographical diversification		Information on geographcial diversification (non-life and health non-SLT)	Yes	FALSE
SF.SCR_G	Link	The standard formula for the SCR according to the QIS5 model	No	TRUE
SF.RFF		For ring fenced funds: Adjustments on SCR and eligible own funds	Yes	FALSE
SF.MCR_G	Link	The QIS5 MCR model	No	TRUE
I.SCR Adjusted	Link	Information on SCR adjusted for intra-group transactions	Yes	TRUE
G.Group OFS		Group informations on other financial sectors and IORPs	Yes	FALSE
G.Group NCP		Group informations on non controlled participations	Yes	FALSE
IM.Internal Model Results		Internal model results compared to the Standard formula	Yes	FALSE
IM.Internal Model Parameters		Internal model parameters	Yes	FALSE
IM "blank" sheet Results		Internal model results based on internal model structure	Yes	FALSE
IM "blank" sheet Parameters		Internal model parameters based on internal model structure	Yes	FALSE
O.Overview	Link	Overview of results	Yes	TRUE
G.Group overview		Overview of group results	Yes	FALSE
G.Group details on aggregation		Details on the aggregation of group data from solo content	Yes	FALSE
D.Dataset	Link	Centralisation of the available informations	No	TRUE
0.Language	Link	Used language and language selector (optional)	Yes	TRUE
QIS5.Lang.??	Link	Variable number of language packs	Yes	TRUE

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6. Conclusions

- Top three perils driving the catastrophe reinsurance purchase – **Wind, Flood, Earthquake**
- Aon Benfield is the only reinsurance broker having the **complete suite of flood and earthquake models covering the territory of Central and Eastern Europe**, including the IF Quake model for Hungary released in 2008
- **Evaluation of third party vendor model** helps to understand the PML drivers and cannot be excluded from the portfolio analysis process
- Solvency II standard formula for Cat gives often controversial results and remains a big challenge for actuaries and Cat modellers.
- Catastrophe model is a the most appropriate solution for quantifying the catastrophe capital requirement