Modelování přírodních katastrof

Jiří Potužil
UNIQA pojišťovna a.s.
8.12.2017

Agenda

Basic concepts of natcat models

- Exposure, hazard, vulnerability, loss (financial module)

Know the peril

- Flood
- Hail
- Windstorm
- Earthquake

Model validation

NatCat risk under Solvency II

- Why is the Solvency II standard formula wrong?

Using materials from NatCat Competence Center, UNIQA Re AG

Role of Nat Cat models in (Re)Insurance

Focus SCOR, December 2012

Catastrophe models are the Swiss-army knives in the Cat Risk Management survival kit – performing multiple functions for insurers including: pricing & risk acceptance decision support, portfolio accumulation management, capital modelling and business planning. Their use is widespread, and they have shaped the very language and framework with which the industry measures and communicates the direct financial risks associated with major natural disasters – and more latterly for man-made disasters too.
The events of 2011 and 2012 have given us all pause for thought, and to question whether these simplified mathematical representations of the destruction potential of incredibly complex natural phenomena will ever be rich enough to adequately capture the myriad uncertainties that lie in wait ready to produce the next "surprise" event: whether levee failure, record surge/cloudburst flooding, nuclear incident, tsunami, regional blackout or political intervention, let alone be sophisticated enough to effectively couple and model dependencies that invariably exist due to large scale weather patterns like El Niño, or the relationship between Property and Agriculture lines of business weather risks.

Nat Cat Model = Simplification of a complex random event

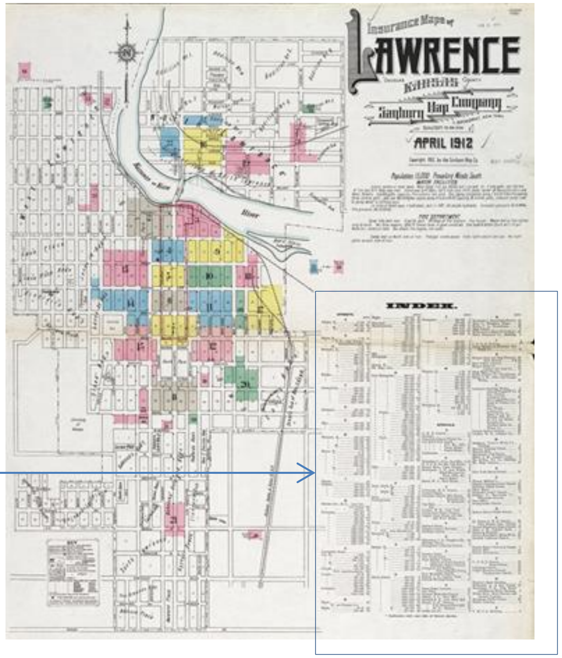
History of NatCat models

Origin of Nat Cat Models

Fire Companies
(19th century)

→

The Sanborn
Map Company



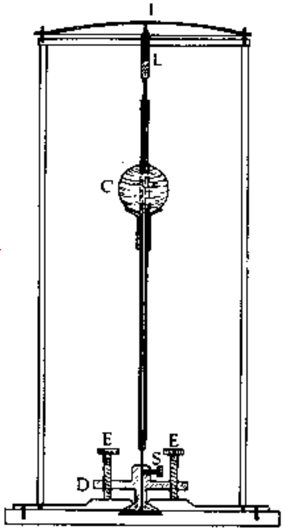
The maps contain an enormous amount of information ("index"):
the location of windows and doors; street names; street and sidewalk widths; property boundaries; fire walls; natural features (rivers, canals, etc.); railroad corridors; building use (sometimes even particular room uses); house and block number; the composition of building materials including the framing, flooring, and roofing materials; the strength of the local fire department; indications of sprinkler systems; locations of fire hydrants; location of water and gas mains; and even the names of most public buildings, churches, schools and businesses.

The common practice of mapping ended in the 1960s when it became too cumbersome and time consuming to execute.

History of NatCat models

In the meantime, somewhere else……

James David Forbes
(1809 –1868)
Scottish Physicist



Forbes' seismometer
(1844)

Thomas Romney Robinson
(1792 - 1882)
Irish Physicist

Thomas' Romney Robinson
anemometer
(1846)

Natural Hazard Science

History of NatCat models

Mapping risk

Development of GIS systems

Measure Hazard

Study about frequency of NatCat evens

Computer- based models

1987 AIR WORLDWIDE

1988 RMS Risk Management Solutions, Inc.

1994 EQECAT CoreLogic

1992- Hurricane Andrew in Florida

- $27.3 billion (in 2017 dollars)
- 9 insurers insolvent
- More sophisticated modeling approach needed

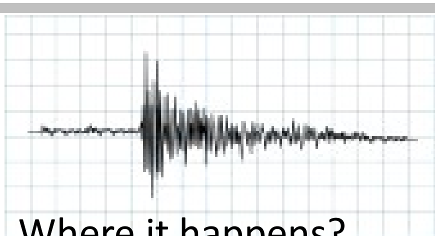
UNIQA RiskManagement

...and in Czech Republic

1997- Floods in Moravia
-> Default of pojišťovna Morava

2002 - Floods in Bohemia
2002 - 2003 Development of the first flood model AON BENFIELD

Structure of NatCat Models



Where it happens?
At which intensity?
How often?

Hazard

Exposure

Where the risks are?
What type of risks?
Policy conditions ?

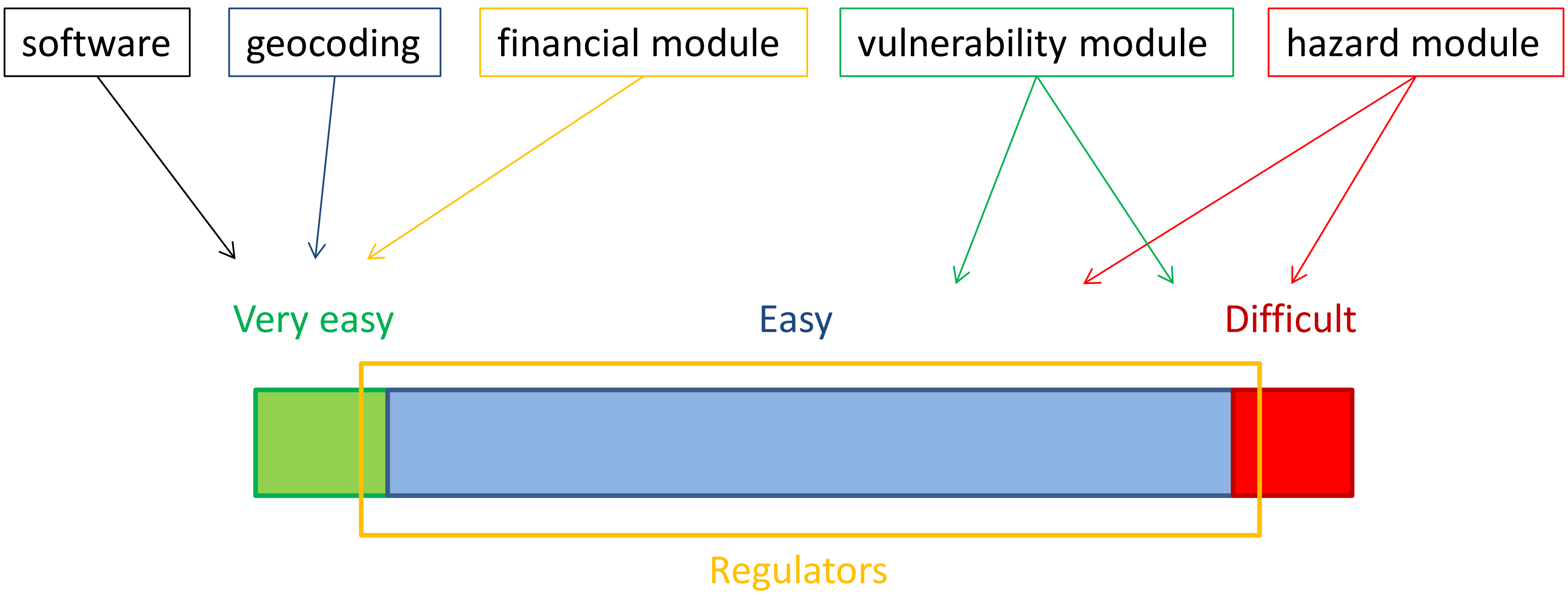
What is the damage?
What is the total loss?

Vulnerability

What is the insured loss?
(after limits & deductibles)

Loss (Financial Module)

To sum up



Difficulty in obtaining the information ≠ difficulty in understanding the model

Model Vendors

[AIR Worldwide]
Founded in 1987 in Boston
http://www.air-worldwide.com

[Risk Management Solutions (RMS)]
Founded in 1988 at Stanford University
http://www.rms.com

[CoreLogic (EQECAT)]
EQECAT Founded in 1994 in San Francisco
http://www.eqecat.com

[Impact Forecasting]
Aon Benfield's catastrophe model development
http://www.impactforecasting.com

[Willis Re]
(Willis Towers Watson)
http://www.willisre.com

... and others

UNIQA RiskManagement

Exposure data

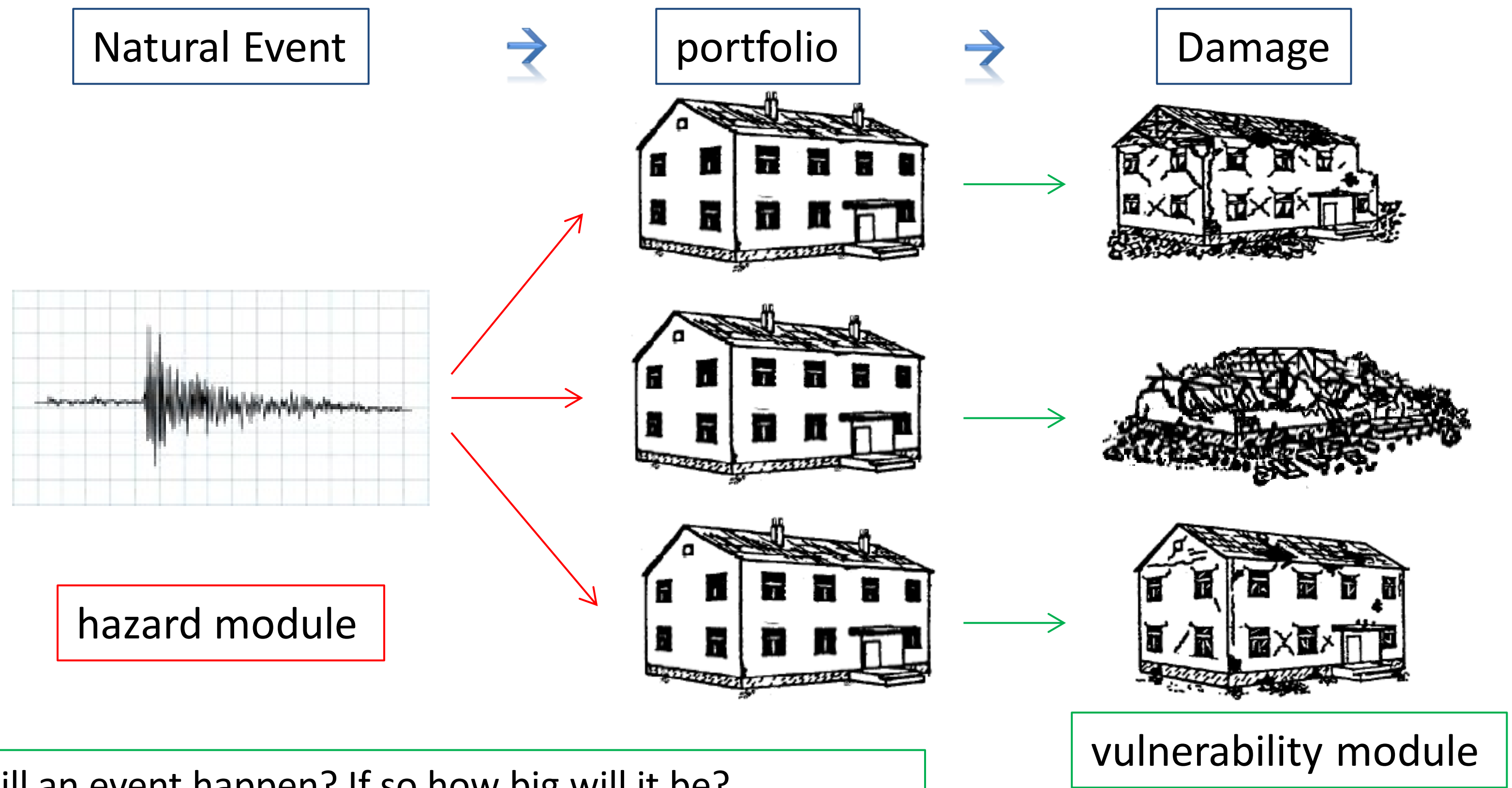
ID	Postal Code	Address (Street, no, City)	Latitude	Longitude	LoB	Building/ content	#Risks	Sum insured

Policy Limit	Deductible absolute	Deductible In % of loss	Occupancy	Number of Stories	Year Build	Basement	Construction	Roof type

Data quality is essential

- More detailed data = more representative view of risk
- Importance of geocoding depends on peril and model resolution
- What is the location of motor business policies, especially fleet
- Multilocations

Hazard and Vulnerability modules



Will an event happen? If so how big will it be?
→ Primary Uncertainty
Given that an event happened (conditional probability) what is the amount of damage it has caused?
→ Secondary Uncertainty

Event data collection

Historical catalogues | Historical books | Art | Geological findings

Date	Magnitude	Epicenter		Name, Location, or Region Affected	Loss of Life and Property
		Latitude	Longitude		
1700, Jan. 26	9.0?	?	?	Offshore, somewhere between Cape Mendocino and Canada	Data not available, but shook northern California, Oregon, Washington, and southern British Columbia; caused tsunami damage to villages in Japan and western US
1800, Nov. 22	6.3?	32.90	-117.80	San Diego/San Juan Capistrano region	Damaged adobe walls of missions in San Diego and San Juan Capistrano
1812, Dec. 8	7.3?	34.37	-117.65	Wrightwood	40 dead at San Juan Capistrano
1812, Dec. 21	7.1?	34.75	-118.60	Los Angeles, Ventura, Santa Barbara	1 dead
1836, June 10	6.4?	36.90	-121.50	Near San Juan Bautista	[Older reports reported this quake as possibly larger and centered near Oakland]
1838, June	7.4?	37.30?	-122.15	San Francisco to San Juan Bautista	Damage to San Francisco and Santa Clara
1852, Nov. 29	6.5?	32.50	-115	Near Fort Yuma, Arizona	
1857, Jan. 9	7.9	36.20	-120.80	Great Fort Tejon earthquake	1 dead; damage from Monterey to San Bernardino County
1860, Mar. 15	6.5?	39.50	-119.50	Carson City	
1865, Oct. 8	6.5	37.20	-121.90	Santa Cruz Mountains	$0.5 million in property damage
1868, Oct. 21	7.0	37.70	-122.10	Hayward Fault	30 dead; $350,000 in property damage

Earthquakes M>6.5, California
http://www.consrv.ca.gov/cgs/rghm/quakes/Pages/eq_chron.aspx

Earthquake in Reggio Calabria (Italy) in 1783.
(Trustees of the British Museum, London)

- All the data is gathered in one single catalogue.
- The catalogue has to be “cleaned up”.
- Properties/parameters/behaviour of the peril are derived.

→Historical catalogue

Hazard Module

Historical Catalogue

+

Geological information
Hydrological information
Meteorological information

+

Research
Stochastic sampling
Global circulation models
Hydrodynamic models
Digital terain models
...

=

Synthetic Event Catalogue

+

How the event behaves in the space-time frame?

=

HAZARD MODULE

UNIQA RiskManagement

Hazard module

Natural Catastrophes

WINDSTORM

- Large territories affected
- Low damage: serious structural damage is rare (destruction of walls, failure of buildings, etc)
- Low number of casualties
- Multi-country losses in Europe

EARTHQUAKE

- Small territories affected
- Usually only single country losses
- Damaging earthquakes are less frequent than
- floods and windstorms.
- High damage: serious structural damage (failure of walls, collapse of buildings, etc)
- Usually high number of casualties

FLOOD

- Flood propagates along river streams and cannot affect large areas continuously
- Lower damage: serious structural damage is not common
- Low number of casualties
- Multi-country losses in Europe
- Loss prevention can be very effective (e.g. flood defences, early warning)

Hail

- Localised events
- Higher frequency
- High share of motor hull losses

Loss Parameters

Windstorm	Wind speed (peak gust)
Earthquake	Intensity
Flood	Inundation depth (distance from flood extent boundary)
Hail	Hailstone size

Vulnerability module

Converts physical characteristics of an event into loss amount

Different vulnerability functions for Line of business , Occupancy...

- Building / content / motor
- Residential / Commercial / Industrial / Agricultural
- Building type, construction, year built, roof type etc. (secondary modifiers)

Data sources

- Claims
- Governments
- Field visits after an event
- Not enough data for most of the perils
  → engineering analyses

The data in the vulnerability module represent most of the intellectual property of the model vendors

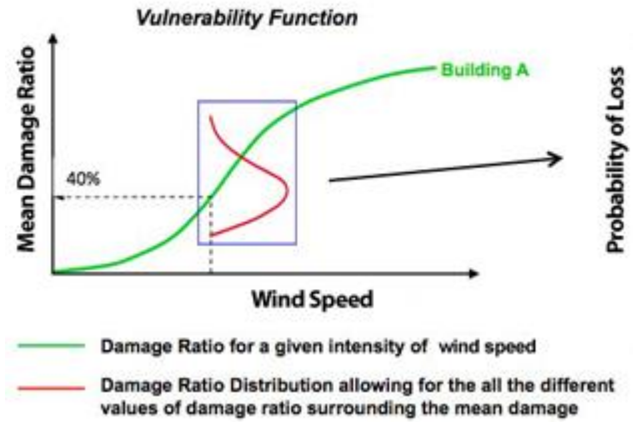
Vulnerability module - secondary uncertainty

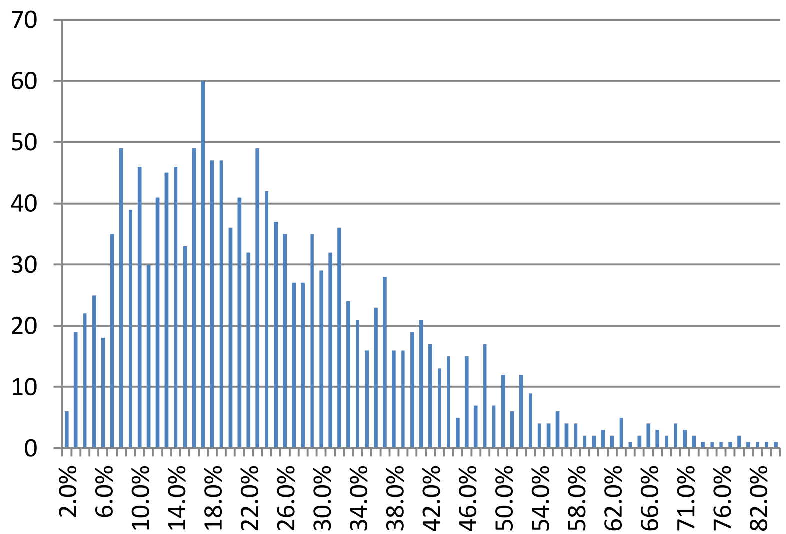
Vulnerability function not deterministic

- Often beta distribution for each hazard intensity

In reality not all risks exposed to hazard claim a loss

- Conditional approach to loss calculation
- Chance of loss (for given hazard intensity) = P(Loss>0)





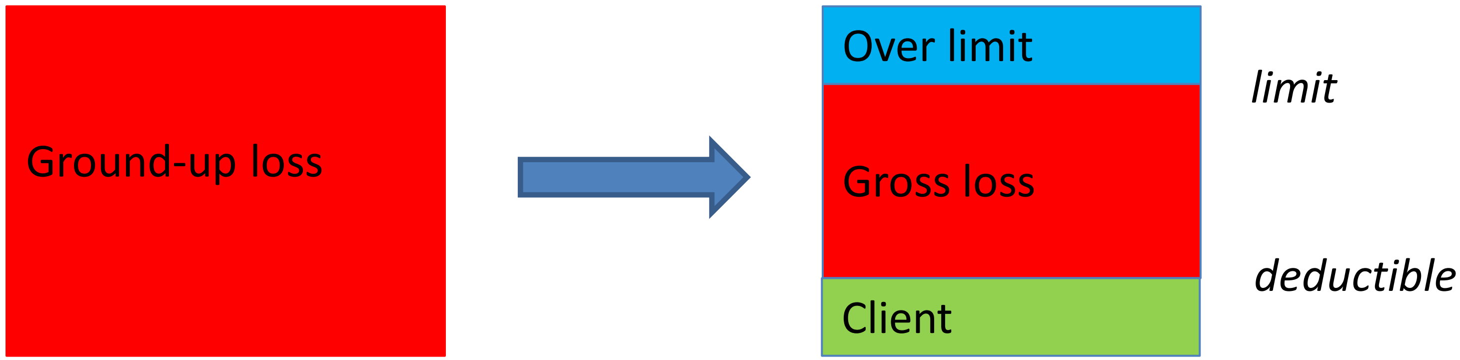
Example of damage ratio claims analysis

Niigata Earthquake, 1964, Source: Wikimedia commons

Financial module

Policy conditions are applied

- limits, deductibles
- per coverage, location, policy

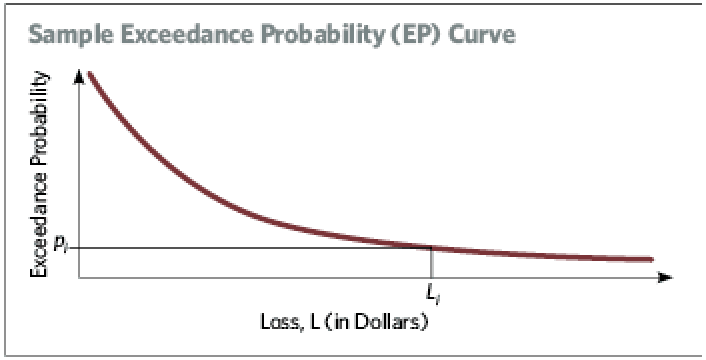


If model includes secondary uncertainty
then it calculates for each event in the event set
a combined loss distribution of all buildings using convolution process

Model outputs terminology

EP (Exceedance Prabability) curve

- = P(loss > x)
- OEP = Occurence Exceedance Prabability
- AEP = Annual Exceedance Prabability
  Poisson distribution usually assumed for event frequency



ELT = Event Loss Tables

YLT = Year Loss Tables

AAL = Average Annual Loss

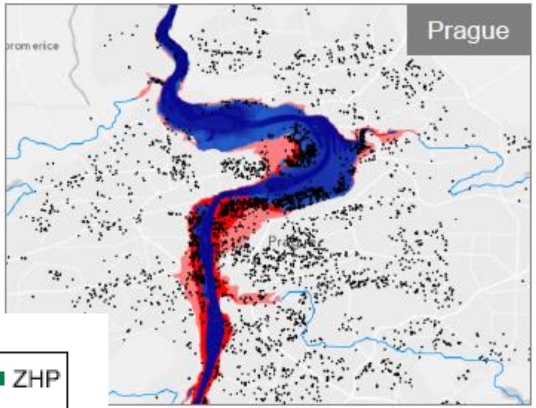
Event ID	Frequency	Mean Loss	Standard Deviation
20038	0.000043	363	852
20174	0.000033	493	1 383
20175	0.000033	10 375	17 033
20176	0.000033	28 691	46 487
20177	0.000033	33 077	49 531
20178	0.000030	39 775	42 645
20179	0.000030	18 479	34 172
20181	0.000027	179	454
20336	0.000027	4 057	8 948
20337	0.000027	47 264	47 341

sample ELT

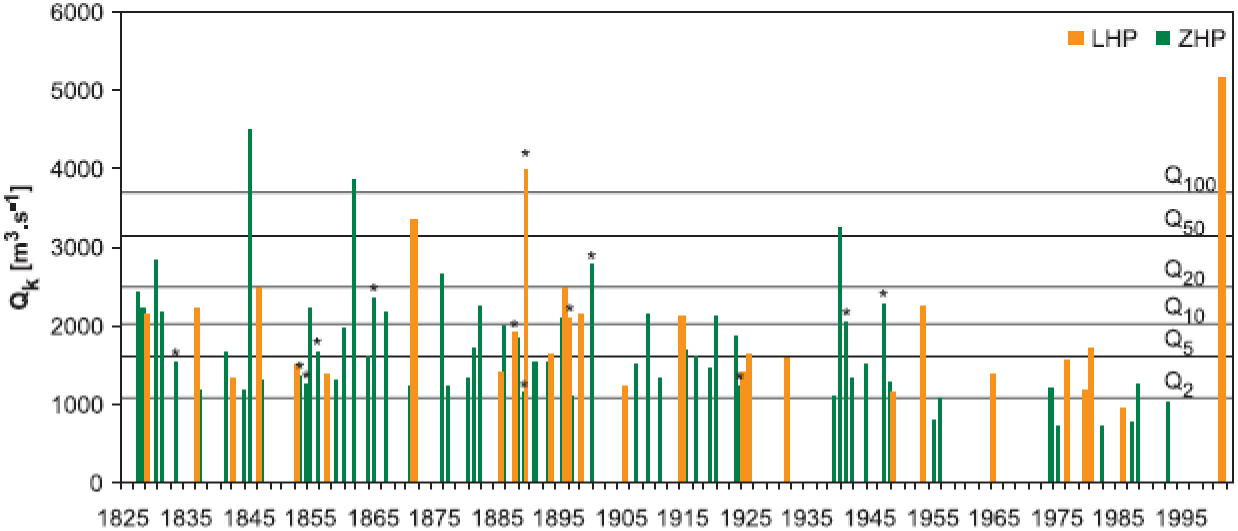
Flood models

Flood types

- Fluvial (riverine) flooding – flood plain & off-flood plain
  - Winter type
  - Summer type
- Pluvial flooding (Cloudbursts, flash floods)
- *Storm surge, Tsunami*



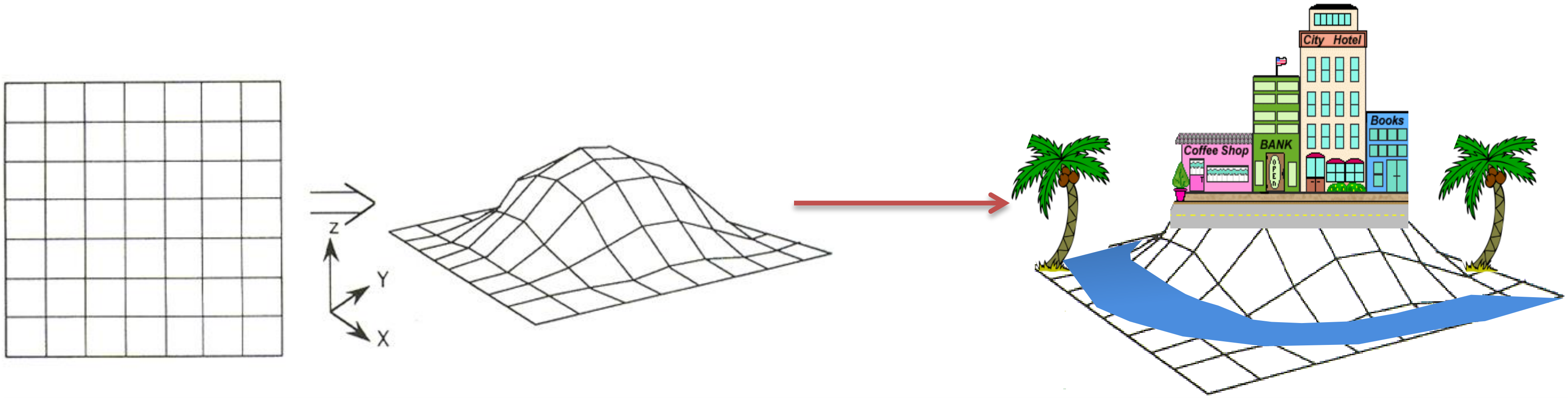
2002 floods reported claims (source: Impact Forecasting)

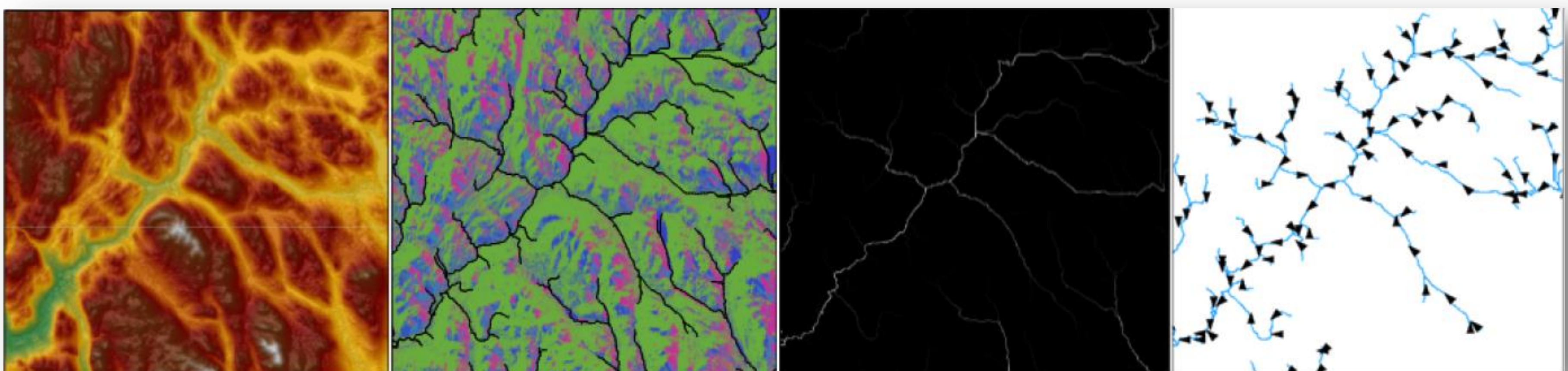


Floods exceeding the 2-year maximum peak discharge of 1090 m3/s on the River Vltava in Prague during the period 1825–2003, taking into consideration their N-year return period and occurrence during the winter) and summer hydrological half-years (ZHP — November–April, LHP — May–October)

Source: Rudolf Brázdil et al.,Historical and recent floods in the Czech Republic, 2005

Flood models - Digital Terrain Model



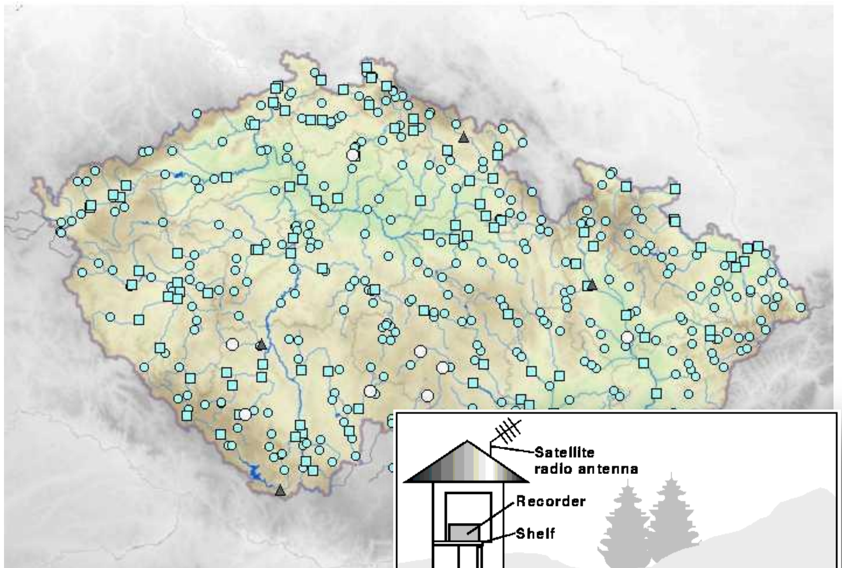


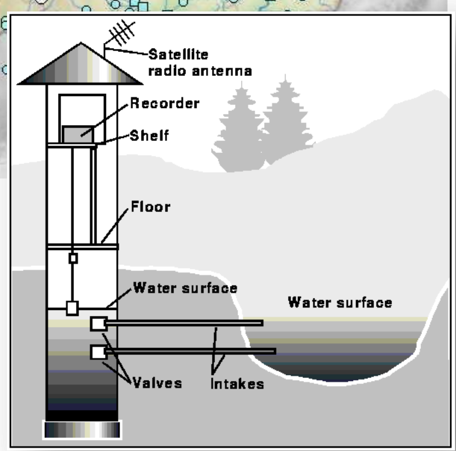
DTM -> Flow direction -> Flow Routing -> River Network delimitation -> Vectorized and oriented river network with geometric network topology (source: Impact Forecasting)

Flood models - event sets generation

Gauging stations data based

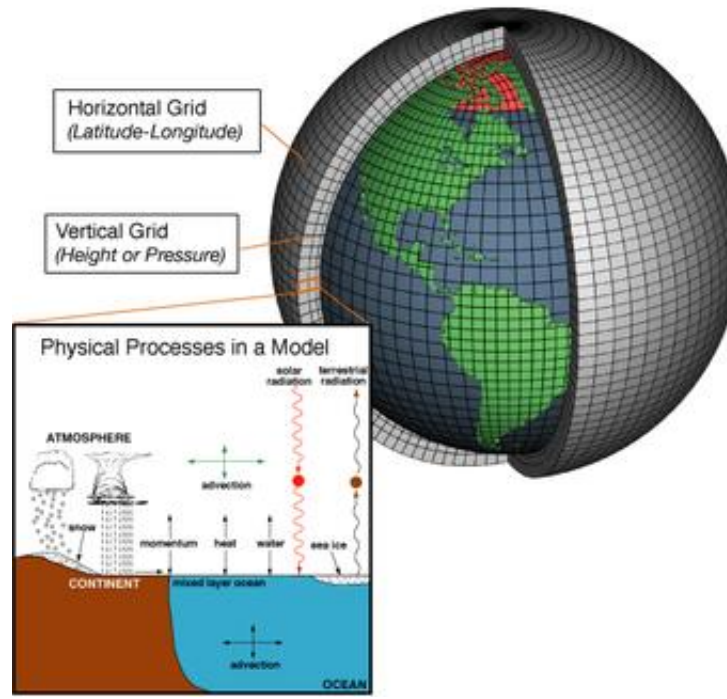
- Gauging stations data
- Statistical dependency model





Global Climate Model (GCM) based

- Stochastic GCM simulation
- Output downscaling/corrections
- Rainfall-runoff processing



Flood models - Hydraulic Modelling

2D Finite differences numerical model

- Describing real physical behavior of flowing water
- Depth and velocities are calculated in each point
- Simulation accuracy driven by DTM and hydrological data

Shallow water equations

http://www.tuflow.com/

$$\frac{\partial \zeta}{\partial t} + \frac{\partial (Hu)}{\partial x} + \frac{\partial (Hv)}{\partial y} = 0$$ (2D Continuity)

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} - c_f v + g\frac{\partial \zeta}{\partial x} + g\,u\left(\frac{n^2}{H^{4/3}} + \frac{f_l}{2g\Delta x}\right)\sqrt{u^2+v^2} - \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) + \frac{1}{\rho}\frac{\partial p}{\partial x} = F_x$$

(X Momentum)

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + c_f u + g\frac{\partial \zeta}{\partial y} + g\,v\left(\frac{n^2}{H^{4/3}} + \frac{f_l}{2g\Delta y}\right)\sqrt{u^2+v^2} - \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right) + \frac{1}{\rho}\frac{\partial p}{\partial y} = F_y$$

(Y Momentum), *Stelling, G.S. (1984):*
On the Construction of Computational Methods for Shallow Water Flow Problems.
Rijkswaterstaat Communications, no. 35/1984, The Hague, The Netherlands

Flood Defences

Dykes and levees

- usually included in DTM

Reservoirs and dry polders

- analysis of gauging stations data
  is there a breakpoint matching
  date of reservoir construction?

Mobile flood protection and walls

- exact characteristics of the defence structure often not available
- therefore not possible
  to be implemented in DTM
  and flood extents modeling
- protected areas
  based on standard of protection

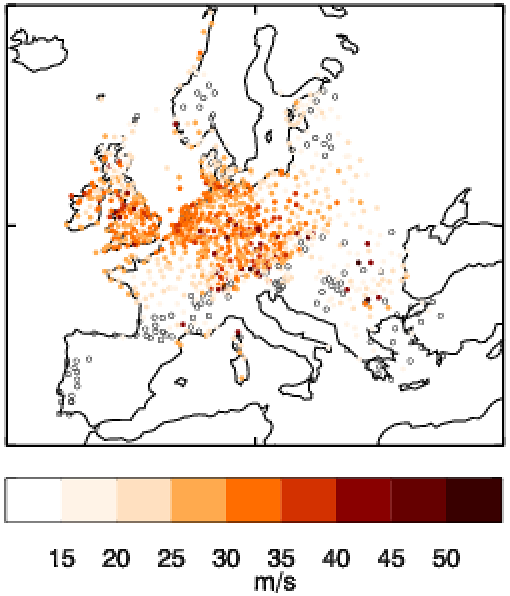
Flood defence failure ?

- stochastic or scenario?

Windstorm models - windstorms in Europe

Winter storms - Extratropical cyclones

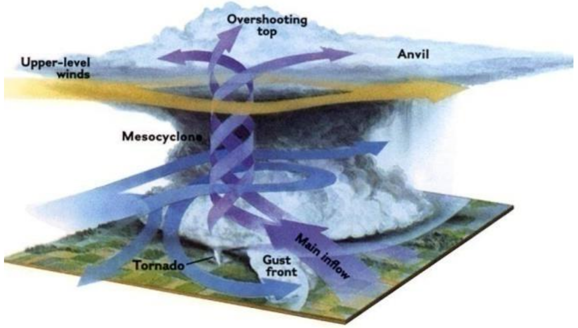
- originate in the North Atlantic basin predominantly in winter subsequently they move eastward across Europe
- large spatial scale covering thousands of square kilometers their life cycle is of about one week
- 2007 - Kyrill
- 2008 - Emma
- 2017 - Herwart



Windstorm Kyrill observed footprint
Source:www.europeanwindstorms.org

Summer storms

- also called thunderstorms
- caused by convectional instability of the atmosphere
- damaging lifecycle 3-6 hours
- can cause severe but localized damage (10-100km)
- sometimes include hail



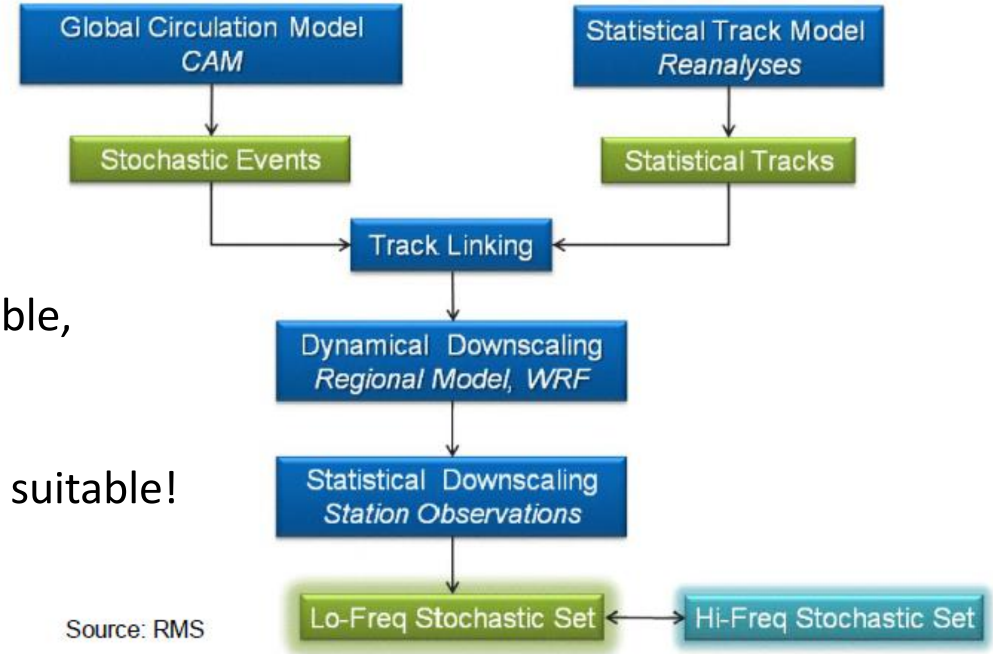
Windstorm models - Event sets generation

Development of synthetic events

1. method of perturbations - modification of historical events
2. variation of initial meteorological conditions of historical events and running a Numerical Weather Prediction (NWP) model
3. using Global Circulation model (GCM) as base

Clustering

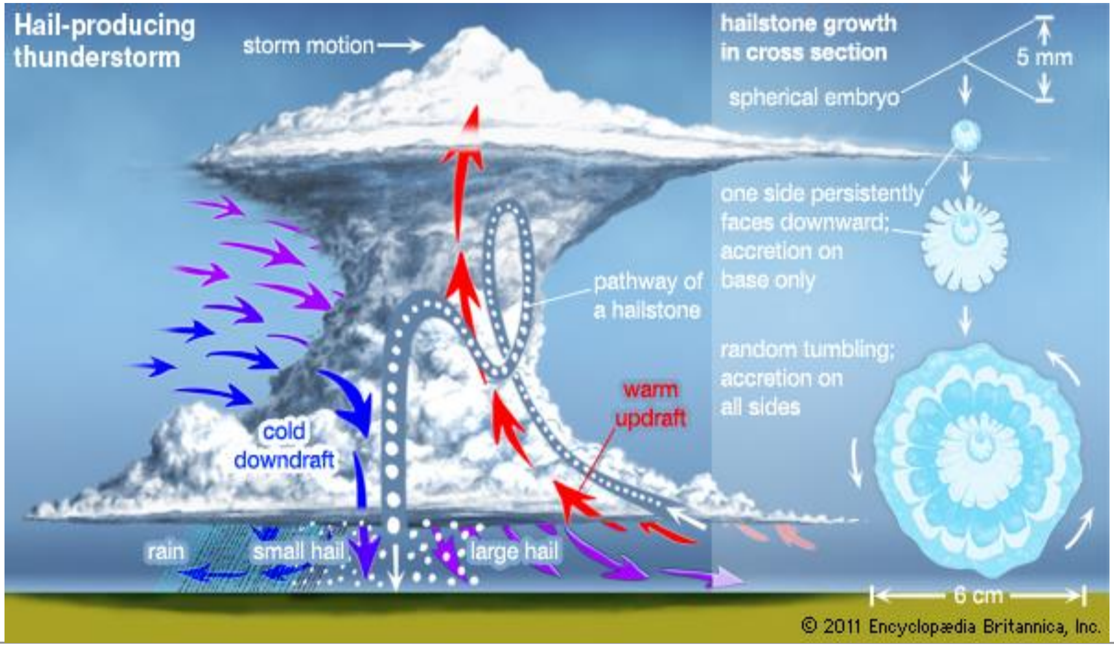
When atmospheric conditions are favorable, storms tend to occur in clusters
→ Storm occurrence not independent
→ Poisson distribution for frequency not suitable!

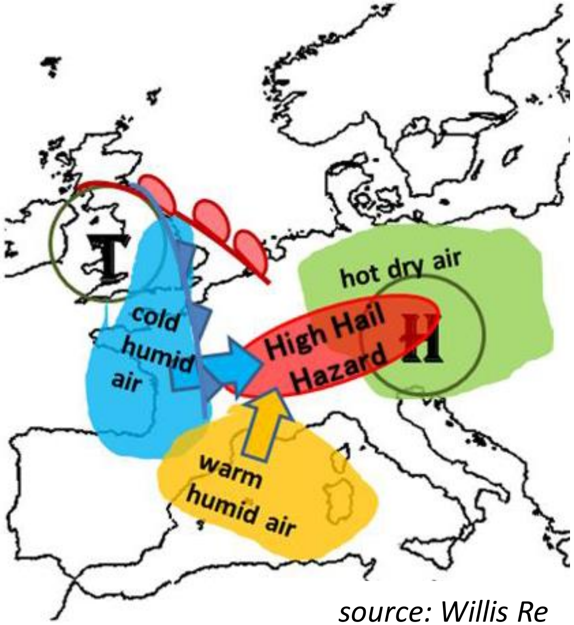


Source: RMS

Hailstorms

- Usually in summer - convective thunderstorms
- Localised, narrow storm tracks
  typical length 10-100km
- Hail damage usually accompanied by wind, rain and lightning damage
- Series of hailstorms over several hours or few days can define one event





source: Willis Re

Hail models - historical catalogue

What is the hazard parameter - hailstone diameter or energy?

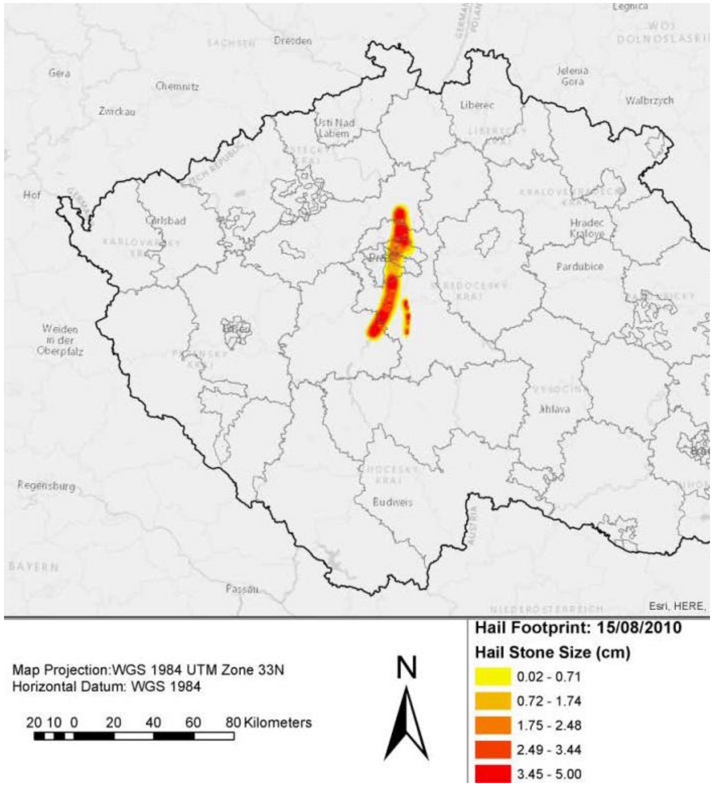
Hail measurement

Direct (On the ground)

- Hailpad networks
- News reports
- http://www.eswd.eu/

Remotely sensed (proxy) evidence

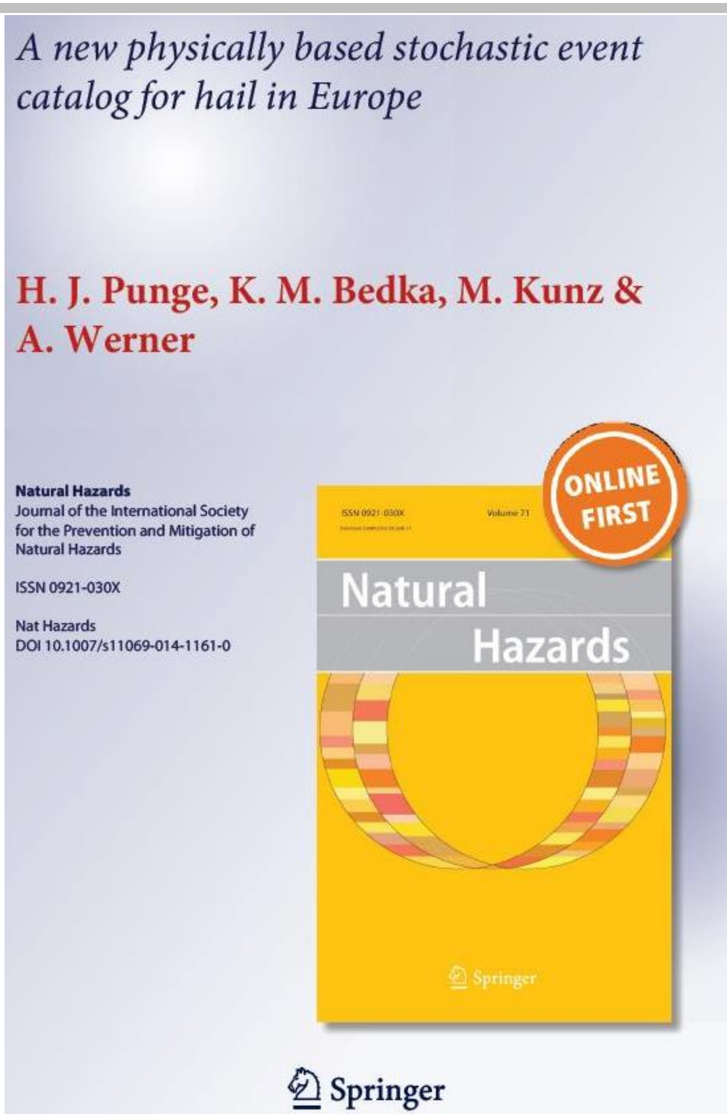
- Radar
- Lightning
- Overshooting tops temperature



15.8.2010 hailstorm track

source: Willis Re

Hail models - Event sets generation



Based on combination of 2 data sets

- Overshooting tops signatures derived from satelite data
- ESWD database

Sampling correlated variables:

- 2.5 x 1.5 degree grid (approx .170x170km in CEE)
- spatial frequency - Poisson distribution

$$f_k(k;\nu) = \frac{\nu^k e^{-\nu}}{k!}$$

- length and width - generalized exponential distr.

$$f_l(l;\lambda) = \lambda e^{-\lambda l} \qquad f_w(w;\kappa) = \kappa e^{-\kappa w}$$

- maximum hailstone size - exponential distribution
- Orientation - normal distribution

$$f_\phi(\phi;\alpha,\beta) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(\phi-\alpha)^2}{\beta^2}}$$

- timing within the year - normal distribution or bimodal normal distribution

Earthquake models - Historical catalogue

Historical catalogue

- going as much as deep to the past is needed
- main source of information used to generate the stochastic event set.
- declustering (no foreshocks and aftershocks)
- homogenization
- completeness test
- zonation

year	month	day	hour	minute	latitude	longitude	depth	intensity	M_{orig}	type	M_w	M_w_err	reference
303			20		33.80	34.30	20	8.5	7.1	S	6.9		SDM
334					36.90	27.40		8	6.6	w	6.6	0.5	Pap
341					36.20	36.10			6	S	6.1		KKP
342					34.75	32.25		9			6.5		GD
344					36.30	28.30		8	6.5	w	6.5	0.5	Pap
361					37.50	14.00		10	6.6	w	6.6	0.3	CPTI04
362	5	24			31.30	35.60			6.5	S	6.5		KKP
363	5	19			31.50	35.50			7.4	S	7.2		Amb06
365	7	21			35.20	23.40			8.4	w	8.4		Sha08
370					38.10	28.90		8	6.5	w	6.5	0.5	Pap
374					38.10	15.65		9.5	6.3	w	6.3	0.2	CPTI04
375	7	12			35.60	24.80		10	7.8	w	7.8	0.5	Pap
412					37.07	10.07		10			7		IGN
417					37.20	29.90		8	6.5	w	6.5	0.5	Pap
448					31.20	34.20			6	S	6.1		KKP
419	11	6			34.80	24.80		8	7.2	w	7.2	0.5	Pap
457	9	14			36.10	36.10			6.3	S	6.3		KKP
459					36.70	27.30		9	6.6	w	6.6	0.5	Pap
476					36.40	28.30		8	6.7	w	6.7	0.5	Pap
494					38.00	29.00		8	6.6	w	6.6	0.5	Pap
494			25		35.80	36.30	25	7.5	6.5	S	6.5		SDM
500					36.20	36.10			7.2	S	7		KKP

GFZ
Helmholtz-Zentrum
Potsdam

http://emec.gfz-potsdam.de/pub/emec_data/emec_data_frame.html

From historical to synthetic catalogue

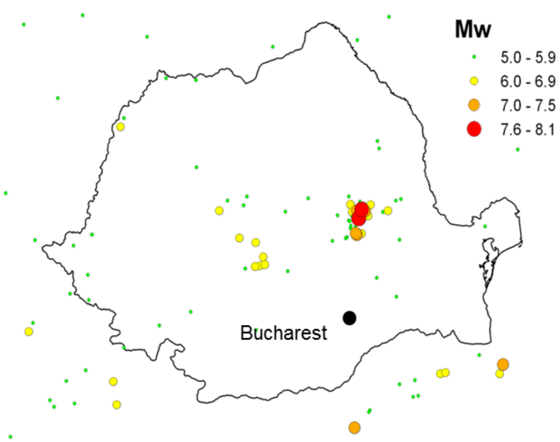
Seismic source model

predefined regions with uniform properties of seismic activity
based on historical observations, geology and tectonics

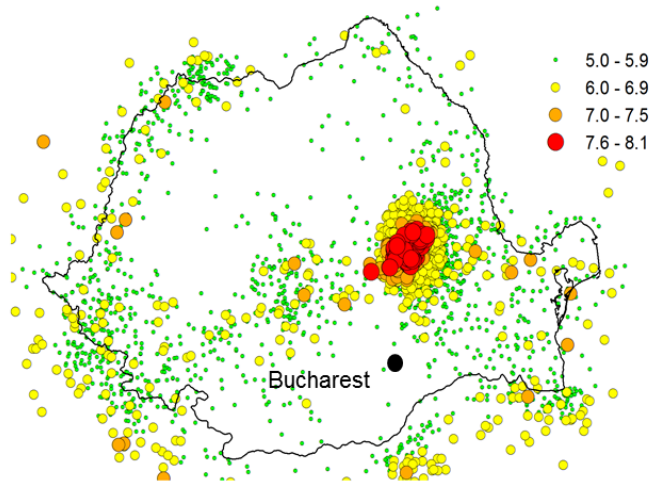
Earthquake recurrence relationship

represents the relationship between magnitude and number of events (rate).

Gutenberg-Richter distribution: $\log_{10}\left(\lambda_{nc}(m)\right) = a - b \cdot m$



Historical catalogue 943-2008



Synthetic Event Catalogue

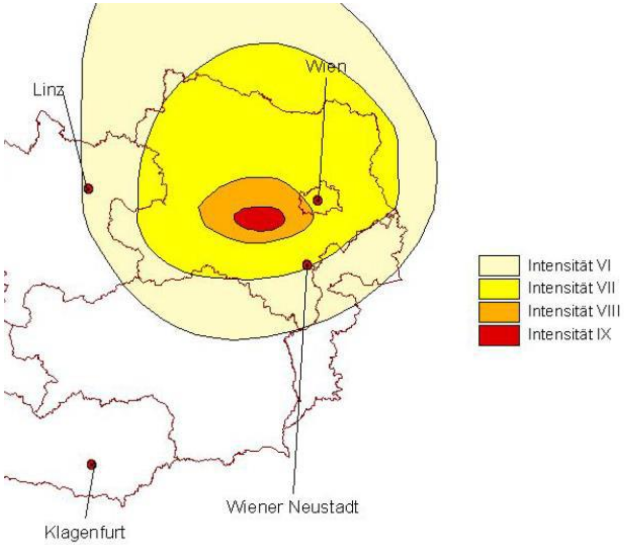
(source: Aon Benfield)

Earthquake - Ground Shaking Attenuation Model

Y represents the ground motion output parameter
depends on the magnitude M of an earthquake occurring at a distance R
and $P_1, P_2, ... P_i$ represent the other event parameters which describe the source, the faulting mechanism, the wave propagation path, local site conditions, etc.
$Y = f(\mathrm{M}, \mathrm{R}, P_1, P_2, \dots P_i)$

Outputs:
Acceleration (PGA, SA)
- could capture different type of response of a building to a different period of ground-shaking
- But very rare historical records

Intensity (EMS -98)
- subjective measure based on the damage
- But the historical evidence goes several centuries back



Reconstruction of Neulengbach 1590 event (source: Munich Re)

Model validation - legislation requirements

Solvency II DIRECTIVE 2009/138/EC

Article 126

External models and data

The use of a model or data obtained from a third party shall not be considered to be a justification for exemption from any of the requirements for the internal model set out in Articles 120 to 125.

Article 120 - Use test
Article 121 -Statistical quality standards
Article 122 - Calibration standards
Article 123 - Profit and loss attribution
Article 124 - Validation standards
Article 125 - Documentation standards

Insurance and reinsurance undertakings shall be able to justify the assumptions underlying their internal model to the supervisory authorities.
Data used for the internal model shall be accurate, complete and appropriate.

But external NatCat model is often a blackbox
Limited documentation available only for licensed users

Possible model validation tests and analyses

Regional distribution of relative average annual loss - compare to hazard maps

Stress testing - are selected extreme events from model event set plausible?

Sensitivity testing - check impact on whole distribution (OEP & AEP)

- occupancy and coverage selection
- geolocation
- limits and deductibles
- secondary uncertainty on/off
- model specific features (clustering, flood defences...)

Stability testing - number of trials, (pseudo)random number generator seed

Backtesting past evens (with known event footprint)

- compare modeled and observed losses
- if current exposure data used, scaling for portfolio changes, inflation ...
- what if these losses were used for vulnerability calibration ?

Return period of past events in modelled OEP / AEP ?

Godness of fit tests

- Kolmogorov-Smirnov test of observed losses (continuous distribution)
- Pearson’s chi-square goodness of fit test for event frequency
- is there enough observations? Cat event threshold set-up!

UNIQA RiskManagement

NatCat risk under Solvency II standard formula

COMMISSION DELEGATED REGULATION (EU) 2015/35

Article 120

Natural catastrophe risk sub-module

1. The natural catastrophe risk sub-module shall consist of all of the following sub-modules:

(a) the windstorm risk sub-module;

(b) the earthquake risk sub-module;

(c) the flood risk sub-module;

(d) the hail risk sub-module;

(e) the subsidence risk sub-module.

assumed =0 in Czech Republic

2. The capital requirement for natural catastrophe risk shall be equal to the following:

$$SCR_{natCAT} = \sqrt{\sum_i SCR_i^2}$$

assumption of independent perils

Article 123

Flood risk sub-module

1. The capital requirement for flood risk shall be equal to the following:

$$SCR_{flood} = \sqrt{\left(\sum_{(r,s)} CorrFL_{(r,s)} \cdot SCR_{(flood,r)} \cdot SCR_{(flood,s)}\right) + SCR^2_{(flood,other)}}$$

NatCat risk under Solvency II standard formula

5. For all regions set out in Annex VII, the specified flood loss in a particular region *r* shall be equal to the following amount:

$$L_{(flood,r)} = Q_{(flood,r)} \cdot \sqrt{\sum_{(i,j)} Corr_{(flood,r,i,j)} \cdot WSI_{(flood,r,i)} \cdot WSI_{(flood,r,j)}}$$

The country factors represent the per-occurrence 99.5% loss for that peril in the country under consideration, as a ratio of the total sums insured in the country.

where:

(a) $Q_{(flood,r)}$ denotes the flood risk factor for region *r* as set out in Annex VII;

(b) the sum includes all possible combinations of risk zones (*i,j*) of region *r* set out in Annex IX;

(c) $Corr_{(flood,r,i,j)}$ denotes the correlation coefficient for flood risk in flood zones *i* and *j* of region *r* set out in Annex XXIV;

(d) $WSI_{(flood,r,i)}$ and $WSI_{(flood,r,j)}$ denote the weighted sums insured for flood risk in risk zones *i* and *j* of region *r* set out in Annex IX.

6. For all regions set out in Annex VII and all risk zones of those regions set out in Annex IX, the weighted sum insured for flood risk in a particular flood zone *i* of a particular region *r* shall be equal to the following:

$$WSI_{(flood,r,i)} = W_{(flood,r,i)} \cdot SI_{(flood,r,i)}$$

There is an underlying assumption of an average vulnerability per peril-country combination, as well as an average deductible and an insured to value relationship

where:

(a) $W_{(flood,r,i)}$ denotes the risk weight for flood risk in risk zone *i* of region *r* set out in Annex X;

(b) $SI_{(flood,r,i)}$ denotes the sum insured for flood risk in flood zone *i* of region *r*.

7. For all regions set out in Annex VII and all risk zones of those regions set out in Annex IX, the sum insured for a particular flood zone *i* of a particular region *r* shall be equal to the following:

$$SI_{(flood,r,i)} = SI_{(property,r,i)} + SI_{(onshore\text{-}property,r,i)} + 1{,}5 \cdot SI_{(motor,r,i)}$$

It is assumed that the undertaking's non- life insurance portfolio is not focused on residential, commercial, industrial or agricultural.

NatCat risk under Solvency II standard formula

2. For all regions set out in Annex VII, the capital requirement for flood risk in a particular region r shall be the larger of the following capital requirements:

(a) the capital requirement for flood risk in region r according to scenario A as set out in paragraph 3;

(b) the capital requirement for flood risk in region r according to scenario B as set out in paragraph 4.

3. For all regions set out in Annex VII, the capital requirement for flood risk in a particular region r according to scenario A shall be equal to the loss in basic own funds of insurance and reinsurance undertakings that would result from the following sequence of events:

(a) an instantaneous loss of an amount that, without deduction of the amounts recoverable from reinsurance contracts and special purpose vehicles, is equal to 65 % of the specified flood loss in region r;

(b) a loss of an amount that, without deduction of the amounts recoverable from reinsurance contracts and special purpose vehicles, is equal to 45 % of the specified flood loss in region r.

4. For all regions set out in Annex VII, the capital requirement for flood risk in a particular region r according to scenario B shall be equal to the loss in basic own funds of insurance and reinsurance undertakings that would result from the following sequence of events:

(a) an instantaneous loss of an amount that, without deduction of the amounts recoverable from reinsurance contracts and special purpose vehicles, is equal to 100 % of the specified flood loss in region r;

(b) a loss of an amount that, without deduction of the amounts recoverable from reinsurance contracts and special purpose vehicles, is equal to 10 % of the specified flood loss in region r.

Sum of these 2 scenarios is 110%

Assumption: 2 events as 99.5% quantile of number of flood events in a year

NatCat risk under Solvency II - ORSA

EIOPA Guidelines on own risk and solvency assessment

Guideline 12 – Deviations from assumptions underlying the SCR calculation

1.26. The undertaking should assess whether its risk profile deviates from the assumptions underlying the SCR calculation and whether these deviations are significant. The undertaking may as a first step perform a qualitative analysis and if that indicates that the deviation is not significant, a quantitative assessment is not required.

The underlying assumptions in the standard formula for the Solvency Capital Requirement calculation

chapter 4.3.1 Natural catastrophe risk

https://eiopa.europa.eu/Publications/Standards/EIOPA-14-322_Underlying_Assumptions.pdf

What about all the assumptions underlying the various external natcat models?
...and their validation?