Catastrophe Risk Management in Practice

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Group Underwriting Excellence
One of few genuinely global insurers

**KEY FACTS**

1. **USD 52bn** total revenues (excl. result on UL investments)
2. **USD 195bn** total group investments (economic view)
3. **USD 4.6bn** business operating profit (BOP)
4. **USD 3.7bn** net income attributable to shareholders (NIAS)
5. **221%** SST regulatory solvency ratio
6. **124%** Zurich Economic Capital (Z-ECM) ratio
7. **USD 30bn** shareholders’ equity
8. **CHF 44bn** market cap

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**A BALANCED GLOBAL BUSINESS**

- **BOP BY BUSINESS (%)**
  - Property & Casualty (incl. Farmers Re): 45%
  - Life: 28%
  - Farmers Management Services: 26%

- **BOP BY REGION (%)**
  - Europe: 32%
  - North America (incl. Farmers): 55%
  - Asia Pacific: 5%
  - Latin America: 8%

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1. Values are for the full year 2018 unless otherwise noted. Investments, solvency ratios, shareholders’ equity and market cap are as of December 31, 2018.
2. The Swiss Solvency Test (SST) ratio as of January 1, 2019 has been calculated based on the Group’s internal model, as agreed with FINMA. The full year ratio has to be filed with FINMA by end of April of each year and is subject to review by FINMA.
3. Values are an average for full years 2016, 2017 and 2018.
4. BOP split by business excludes Group Functions & Operations and Non-Core Businesses. BOP split by region excludes additionally Group Reinsurance.
Hurricane Hugo demonstrated that the risk is real and accelerated the development of cat models

- Hurricane Hugo landfalling in South Carolina, US in September 1989 as a cat 4 storm (SS scale)
- 78 victims
- Insured loss of USD 9bn (2017 USD)
- Most expense insured nat cat loss at the time
- Followed by hurricane Andrew in 1992 as a cat 5 storm with an insured loss of USD 28bn

AIR introduces first modern, computer-based cat model

Hurricane Andrew makes landfall in Southern Florida

Paper on cat management

Hurricane Hugo makes landfall in South Carolina

1985 1987 1989 1992

Hurricane Hugo track (top) and Andrew (Wikipedia)
Global risks are intensifying, with environmental threats perceived as issues of the greatest concern.
Environmental risks dominate for the third year in a row

- Weapons of mass destruction
- Failure of climate change mitigation and adaptation
- Extreme weather events
- Biodiversity loss and ecosystem collapse
- Natural disasters
- Man-made environmental disasters
- Data fraud or theft
- Large-scale involuntary migration
- Asset bubbles in a major economy
- Critical information infrastructure breakdown
- Spread of infectious diseases
- Water crises
- Economic crises
- Man-made environmental disasters
- Cyber attacks
- Critical information infrastructure breakdown
- Spread of infectious diseases
- Water crises
- Economic crises
- Man-made environmental disasters
- Cyber attacks
Zurich’s ERM framework is governed by the three lines of defense approach

Effective risk management lies on great collaboration among all departments across an organization.

1st LoD

**Business Management** takes risks and is responsible for day-to-day risk management.

2nd LoD

**Group Risk Management** and **Group Compliance** provide the frameworks to manage risks, independent challenge, oversight, monitoring and advice to support the first line in managing risks.

3rd LoD

**Audit** provides independent and objective assurance regarding the adequacy and effectiveness of the Group’s risk management, internal controls and governance processes.
Group Accumulation Management looks at different scenarios leveraging our experience for natural catastrophe risk.

**The Zurich Way of Accumulation Management** proactively identifies and understands risk accumulations across lines of business and any loss scenarios, equipping market facing units to take appropriate underwriting action to manage risk.

This is achieved in a timely, globally consistent and efficient way, relying on thought leadership and simple processes.
The strength of Zurich’s accumulation management is built on a global best practice and a leading level of standardization

Global mandate
– Proactively identify and understand risk accumulations across all LOBs and all business units
– Equip units to take appropriate underwriting action to manage risk
– Strong engagement with external industry and academic bodies

Global Risk Policy and Guidelines
– Underwriting approach and risk appetite defined by internal guidelines
– Governed by financial control framework
– Technical Underwriting Reviews with focus on Catastrophes

Leading level of standardization
– Exposure data standards and controls (validation/sign off) in the Risk Exposure Data Store (REDS)
– Manuals for global consistency (Cat Modeling, Developing the ‘Zurich View’, Cat Event Response)
– Global suite of catastrophe models licensed from leading model vendors as basis for the ‘Zurich View’
– Culture of continuous improvements
General architecture of natural catastrophe models

**Exposure data**
Describes the type of risk insured value and location

**Hazard Module**
Calculates the hazard intensity at a certain location based on a probabilistic event set

**Vulnerability Module**
Converts hazard to a damage ratio through vulnerability curves

**Financial Module**
Calculates the ground up loss and splits the loss into different financial perspectives

**Results Data**
Contains the calculated losses by event (event loss table) from where we can calculate:
- Risk Premium/expected loss
- Single event/Annual aggregate losses (e.g. 100 year)
- Risk Based Capital (RBC), reinsurance, etc.
Scope of modeled natural catastrophe peril regions and Group-wide risk aggregation

Probabilistic Group Cat Model
- 10 mio risk locations
- 39 quasi independent peril regions
- 1.9 mio probabilistic events
- 200’000 years of cat events per run
2011 as an example of high accumulation of natural catastrophe losses

Figure 3
Insured catastrophe losses, 1970–2018 (USD billion, in 2018 prices)

1. Hurricane Andrew
2. Winter Storm Lothar
3. WTC
4. Hurricanes Ivan, Charley, Frances
5. Hurricanes Katrina, Rita, Wilma
6. Hurricanes Ike, Gustav
7. Japan, NZ earthquakes, Thailand flood
8. Hurricane Sandy
9. Hurricanes Harvey, Irma, Maria
10. Camp Fire, Typhoon Jebi

Source: Swiss Re Institute
Reinsurance program in line with Group risk appetite

**GROUP CATASTROPHE REINSURANCE PROTECTION (USDm)**

<table>
<thead>
<tr>
<th></th>
<th>Retention</th>
<th>10% co-participation</th>
<th>Regional cat treaties</th>
<th>Global cat treaty</th>
<th>US wind swap</th>
<th>Combined global cat treaty 2</th>
<th>Global aggregate cat treaty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe all perils 1</td>
<td>487</td>
<td>200</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>447</td>
<td>200</td>
</tr>
<tr>
<td>US all perils (incl. earthquakes)</td>
<td>600</td>
<td>200</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>447</td>
<td>200</td>
</tr>
<tr>
<td>Rest of World all perils</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>300</td>
<td>200</td>
</tr>
</tbody>
</table>

2. This USD 200m cover can be used only once, either for aggregated losses or for an individual occurrence or event.
3. Franchise deductible of USD 25m, i.e., losses greater than USD 25m count towards erosion of the retention (annual aggregate deductible).
Own view of natural catastrophe risk introduced in 2005: the ‘Zurich View’

RATIONALE
- Understanding Cat models is important, but does not give own risk view yet
- ‘All models are wrong, but some are useful’ (by George Box, 1976)
- Models represent the industry average but no one is the average
- Model validation and calibration required to reflect loss experience
- Embrace model sophistication, but not blinded by it

EXAMPLE: US EARTHQUAKE
- A collaboration approach with Advisory Council for Catastrophes (ACC) member Dr. Ross Stein was taken – a proof point of tangible value from the AAC.
- The enhancement of vendor models based on our internal ‘Zurich view’ of risk is industry leading facilitating the incorporation of new scientific insights faster than commercial vendor models
- For US Earthquake, the changes in the USGS hazard maps (2014) where integrated into Zurich’s Risk View two years ahead of any commercial model.

EXAMPLE: US HURRICANE
- Detailed US hurricane claims data (15 years, 18 hurricanes) were matched to Zurich’s complete exposure data and augmented with meteorological data.
- This study facilitated an in-depth validation and calibration of the RMS US hurricane model and lead to refinements in several model components (storm frequency, surge wind contribution and vulnerability).
- Zurich’s claims data matched with meteorological data from hurricane Sandy
Cat event response reporting for hurricanes Harvey, Irma and Maria in 2017

HARVEY

- Texas landfall as cat 4, 2nd landfall in Louisiana as a tropical cyclone
  - First major hurricane to make landfall in the US since Wilma in 2005
  - Rainfall record from a tropical cyclone in the continental U.S. (1.32 m)
  - Industry loss USD 30bn\(^1\)

IRMA

- Barbuda and Cuba landfalls as cat 5
- Florida US landfall as cat 4, 2nd Florida landfall as cat 3 hurricane
- Strongest storm that has ever existed in the Atlantic outside Caribbean and Gulf of Mexico
- Industry loss USD 30bn\(^1\)

MARIA

- Dominica landfall as cat 5, Puerto Rico as Cat 4
- Industry loss USD 32bn\(^1\)

MAIN CHALLENGES

- Need to assess losses from wind, storm surge and inland flooding
- Significant proportion of total loss from inland flooding, especially Harvey
- Commercial inland flood models are still emerging

\(^1\) Source: Swiss Re Sigma (2018)
Seismic risk change project in Chile following the 2010 M8.8 Maule event inspired to more dynamic modeling
Since the first cat models introduced in the late 1980s, the increase in computing power and improved science support much more sophistication in simulation processes.

However, model sophistication may give a false sense of accuracy.

Not a new topic (e.g. David Miller 1999), but often much overlooked.

Real world systems are immensely complex and models that attempt to simulate them are material simplifications.

Model based informed decision-making requires a solid understanding of the uncertainty in models and good awareness of model limitations.

→ Insist on transparency and quantify.

Chi-Chi Earthquake Taiwan, 1999. Differing damage for same buildings at same location.
Propagation of primary and secondary uncertainty through cat models

**Hazard**
- Event generation

**Local intensity**

**Vulnerability**
- Damage estimation

**Exposure**
- Exposure data

**Financial**
- Insured loss
  - Insurer
  - Deductible

**Primary uncertainty**

**Secondary uncertainty**

**Increasing uncertainty**
Computation intensive cat modeling

- Catastrophe models are different from weather and climate prediction models
  - Need to have 10k to 100k years of ensemble members
  - Use more statistical methods
  - Have a hazard resolution at the impact scale, e.g. 10m for floods
  - They need to be able to compute impacts of future climate changes
- Heavy compute power needed to compute US inland flood model on 10m
## Climate change scenarios and potential impact on perils regions

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>Metric</th>
<th>Benchmark Period</th>
<th>Changes</th>
<th>To the Present</th>
<th>1.5°C</th>
<th>2°C</th>
<th>&gt;2°C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heat Waves</strong></td>
<td>Land fraction warmer than prior record</td>
<td>1850-1920</td>
<td></td>
<td>10-20%</td>
<td>50-60%</td>
<td>80%</td>
<td>&gt;80%</td>
</tr>
<tr>
<td></td>
<td>(High)</td>
<td></td>
<td></td>
<td>(Med-High)</td>
<td>(Med-High)</td>
<td>(Med-High)</td>
<td>(Med-High)</td>
</tr>
<tr>
<td><strong>Heat Stress</strong></td>
<td>% Days for external labour</td>
<td>1881-1910</td>
<td></td>
<td>90%</td>
<td>79-80%</td>
<td>60-70%</td>
<td>&lt;50%</td>
</tr>
<tr>
<td></td>
<td>(High)</td>
<td></td>
<td></td>
<td>(High)</td>
<td>(High)</td>
<td>(High)</td>
<td>(High)</td>
</tr>
<tr>
<td><strong>Drought</strong></td>
<td>% land in drought that exceeds historical levels</td>
<td>1916-2016</td>
<td></td>
<td>Small increasing trend (Med-High)</td>
<td>Large increases some regions (Med-High)</td>
<td>Increasing # of regions impacted (Med-High)</td>
<td>In most regions unrecorded drought levels become the norm (Med-High)</td>
</tr>
<tr>
<td></td>
<td>(Med-High)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum intensity</td>
<td>As above</td>
<td>Nil global from 1975-2010 (High)</td>
<td>&lt;10%</td>
<td>10-20%</td>
<td>5-10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Med-High)</td>
<td></td>
<td></td>
<td>(Med-High)</td>
<td>(Med-High)</td>
<td>(Med-High)</td>
<td></td>
</tr>
<tr>
<td><strong>Sea Level Rise</strong></td>
<td>Global Mean</td>
<td>1970</td>
<td>~100% between 1975-2010 (High)</td>
<td>Small increase from 2010-2015 (Med)</td>
<td>Small increase from 2010-2015 (Low)</td>
<td>Small increase from 2010-2015 (Low)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regional (includes land movement)</td>
<td>Annual changes used</td>
<td>-2 to 10 mm/y (High)</td>
<td>Highly variable around the global mean (High)</td>
<td>Highly variable around the global mean (High)</td>
<td>Highly variable around the global mean (High)</td>
<td></td>
</tr>
<tr>
<td><strong>Tropical Cyclone Surge</strong></td>
<td>Probability of major storm</td>
<td>1980-2000 for future changes</td>
<td>Probability has increased 2 times over 20th century (Med-High)</td>
<td>Further increase (Med)</td>
<td>Further increase (Med)</td>
<td>Increase 2-20 times to 2100 with potential for unheard of surge levels (Med-Low)</td>
<td></td>
</tr>
<tr>
<td><strong>Extreme Rainfall</strong></td>
<td>Percentage of events &gt;historical 99% level</td>
<td>1976-2005</td>
<td>Regionally variable generally slightly upward</td>
<td>Regionally variable 7-8% (Med-High)</td>
<td>Regionally variable 13-15% (Med-High)</td>
<td>Potentially 300% increase in 99% level occurrences (US example) (Med-Low)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Size of extreme rainfall system</td>
<td>1980-2010</td>
<td>No info</td>
<td>No info</td>
<td>No info</td>
<td>No info</td>
<td></td>
</tr>
<tr>
<td><strong>Large Hail</strong></td>
<td>Frequency of hail &gt;2.5 cm diameter</td>
<td>1980-2010</td>
<td>Increasing trend Europe, little change in US and Australia (High)</td>
<td>No info</td>
<td>No info</td>
<td>No info</td>
<td>Regionally and seasonally dependent substantial increase (Med)</td>
</tr>
</tbody>
</table>

Source: Zurich’s Advisory Council for Catastrophes (Q4 2017)
## Evolution of terrorism risk assessment

<table>
<thead>
<tr>
<th>Method</th>
<th>Exposure Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeled, building level</td>
<td>Loss modeling</td>
</tr>
<tr>
<td>In-house modeling, building level</td>
<td>Loss modeling</td>
</tr>
<tr>
<td>Accumulation, building level</td>
<td>Exposed sum insured</td>
</tr>
<tr>
<td>Accumulation, postal code level</td>
<td>Exposed sum insured</td>
</tr>
<tr>
<td>Accumulation, city level</td>
<td>Exposed sum insured</td>
</tr>
<tr>
<td>Maximum exposure, location level</td>
<td>Exposed sum insured</td>
</tr>
<tr>
<td>Maximum exposure, account level</td>
<td>Exposed sum insured</td>
</tr>
</tbody>
</table>

From semi-manual to...

…automated, building level assessment

...to 3D Computational Fluid Dynamics (CFD) analysis (by Aon IF)
From traditional data quality management to managing exposure data enhancement

Effective exposure data quality management for submission data

Data Quality Framework
- Completeness
  - Data
  - Completeness Index
- Accuracy
  - Underwriting
  - Review
- Consistency
  - Data validation checks

Exposure data enhancement

Logos for Sanborn, Zesty.ai, Deloitte, Verisk, Google, and Insurdata
Emerging risks (e.g. Cyber) are very different from Nat Cat...

- Virtual vs physical
- Dynamic vs static
- Long vs short tail
- Human impact/jurisdiction
- Global vs local/regional
- Level of standardization
- Availability of data (exposure&claims)
- Model sophistication
Emerging risks (e.g. Cyber) are very different from Nat Cat but there is a great cross learning opportunity

- Virtual vs physical
- Dynamic vs static
- Long vs short tail
- Human impact/jurisdiction
- Global vs local/regional
- Level of standardization
- Availability of data (exposure&claims)
- Model sophistication

- Own the view of risk
- Minimize ‘Non-modeled’
- Avoid model overreliance
- Take a risk based approach
- Develop/use standards
- Centralize exposure data source
- Events are learning opportunities
- Access to hazard expertise
CyberShake - A SCEC research project to develop a physics-based computational approach to probabilistic seismic hazard analysis
Q&A session
Thank you for your attention

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