Practical Stress Testing using Realistic Disaster Scenarios

Will Gardner

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This presentation has been prepared for the Actuaries Institute 2012 General Insurance Seminar. The Institute Council wishes it to be understood that opinions put forward herein are not necessarily those of the Institute and the Council is not responsible for those opinions.
Aim of the Research

• To develop a methodology and a series of realistic disaster scenarios (RDS) to provide insurers with property exposures in Australia a practical approach for stress testing against loss from physical catastrophes
The Need for an RDS Approach

• Concentration risk management
  – APRA identified “a lack of analysis using stress testing or scenario analysis to set the risk appetite” in a recent industry review

• Less complex approach
  – Easily understood by non-technical board members

• Good practice
  – Multi-model doesn’t just mean running multiple stochastic cat models
Existing Global Approaches

- Lloyds
  - 10+7 predefined events >USD100bn
  - Includes double events
  - Event Damage Factor tables
- Karen Clark and Company
  - “Characteristic Events”
  - Events are “floated” to ensure stability
Scope

- Geographical
  - Australia

- Classes
  - Residential, commercial, industrial, motor

- Perils
  - Cyclone, earthquake, bushfire, flood, storm, hail
RDS approach

1. Develop insurance industry Probable Maximum Loss (PML) curves by peril
2. Determine all perils industry PMLs
3. Define scenarios for each peril to demonstrate individual and all perils losses at the 1-in-100 and 1-in-200 year levels
4. Apply scenarios to insurance portfolios to estimate RDS losses
RDS approach (continued)
Previous research

- Industry exposure → Redo
- Cyclone model → Rescale
- Earthquake model → Rescale
- Other Perils model → Redo
- Terrorism → Remove

1. Develop insurance industry Probable Maximum Loss (PML) curves by peril
2. Determine all peril industry PMLs
3. Define scenarios for each peril to demonstrate individual and all perils losses at the 1-in-100 and 1-in-200 year levels
4. Apply scenarios to insurance portfolios to estimate RDS losses
Inflation

- Population growth
  - ABS Census 2011 Estimated Resident Population Australia
- Inflation
  - CPI All Groups Australia
- Wealth
  - GDP per capita: Chain volume measure

- Applied to exposures and losses to 1/1/2013
Cyclone

Event set simulation
- Full tracks generated from 100 starting gates

Hazard and loss
- Allows for terrain, topography and local building codes

Financial adjustments
- Includes demand surge and scaled to 1/1/2013
Earthquake

Event set simulation
- Australian and Indonesian events on land and under sea

Hazard and loss
- Allows for soil effects and improvements from building codes

Financial adjustments
- Includes demand surge and scaled to 1/1/2013
Losses for “Other Perils”

- Industry losses from ICA event list, rescaled to 1/1/2012 by Risk Frontiers
- Rescaled to 1/1/2013 and ranked to create low return period PML curves
- Upper limits fitted to published research on maximum potential events
## Top ICA Events (1967-2012)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>State</th>
<th>Deaths</th>
<th>Homes destroyed</th>
<th>Rescaled Insured Loss ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb-83</td>
<td>‘Ash Wednesday’</td>
<td>Vic &amp; S.A</td>
<td>76</td>
<td>2,450</td>
<td>1,901</td>
</tr>
<tr>
<td>Feb-09</td>
<td>‘Black Saturday’</td>
<td>Vic</td>
<td>173</td>
<td>2,000</td>
<td>1,340</td>
</tr>
<tr>
<td>Jan-03</td>
<td>Canberra</td>
<td>ACT</td>
<td>4</td>
<td>500</td>
<td>699</td>
</tr>
<tr>
<td>Feb-67</td>
<td>Hobart</td>
<td>Tas</td>
<td>?</td>
<td>1,454</td>
<td>646</td>
</tr>
<tr>
<td>Jan-94</td>
<td>Sydney &amp; other</td>
<td>NSW</td>
<td>4</td>
<td>?</td>
<td>228</td>
</tr>
</tbody>
</table>

## Other Significant Events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>State</th>
<th>Deaths</th>
<th>Homes destroyed</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1898</td>
<td>‘Black Tuesday’</td>
<td>Vic</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>1851</td>
<td>1851 ‘Black Thursday’</td>
<td>Vic</td>
<td>15</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>1939</td>
<td>‘Black Friday’</td>
<td>Vic &amp; NSW</td>
<td>68</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>1957</td>
<td>Leura Blue Mtns</td>
<td>NSW</td>
<td>13</td>
<td>231</td>
<td></td>
</tr>
<tr>
<td>1926</td>
<td>Gippsland</td>
<td>Vic</td>
<td>41</td>
<td>227</td>
<td></td>
</tr>
<tr>
<td>1943/44</td>
<td>West, Central, South</td>
<td>Vic</td>
<td>54</td>
<td>642</td>
<td></td>
</tr>
</tbody>
</table>

Note: “Homes destroyed”, “Houses damaged” and “Housing Equivalents” are often used interchangeably by media and the scientific community making historic comparisons difficult.
**Bushfire**

**PML (AUD $m)**

<table>
<thead>
<tr>
<th>Return Period (Years)</th>
<th>RDS Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>• Blue Mountains</td>
</tr>
<tr>
<td>1.0</td>
<td>• Adelaide Hills</td>
</tr>
<tr>
<td>10.0</td>
<td>• SE/SW Victoria, Gippsland, Dandenongs</td>
</tr>
<tr>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>1,000.0</td>
<td></td>
</tr>
</tbody>
</table>

**Maximum Loss**

- $4 billion (but multi-event potential across a wide area is high)
## Top ICA Events (1967-2012)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>State</th>
<th>Deaths</th>
<th>Homes destroyed</th>
<th>Rescaled Insured Loss ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-74</td>
<td>Brisbane flood (TC Wanda)</td>
<td>QLD</td>
<td>15</td>
<td>1,526</td>
<td>2,800</td>
</tr>
<tr>
<td>Feb-11</td>
<td>Brisbane catchment</td>
<td>QLD</td>
<td>35</td>
<td>?</td>
<td>2,652</td>
</tr>
<tr>
<td>Nov-84</td>
<td>Sydney</td>
<td>NSW</td>
<td>6</td>
<td>?</td>
<td>612</td>
</tr>
<tr>
<td>Apr-74</td>
<td>Sydney</td>
<td>NSW</td>
<td>?</td>
<td>?</td>
<td>539</td>
</tr>
<tr>
<td>Feb-08</td>
<td>Mackay</td>
<td>QLD</td>
<td>?</td>
<td>2,000</td>
<td>537</td>
</tr>
<tr>
<td>Feb-11</td>
<td>Melbourne</td>
<td>Vic</td>
<td>?</td>
<td>?</td>
<td>437</td>
</tr>
</tbody>
</table>

## Other Significant Events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>State</th>
<th>Deaths</th>
<th>Homes destroyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>Parsons-Hunter. Singleton, Maitland, Bulga</td>
<td>NSW</td>
<td>35</td>
<td>1,753</td>
</tr>
<tr>
<td>1950</td>
<td>Grafton-Kempsey</td>
<td>NSW</td>
<td>5</td>
<td>360</td>
</tr>
<tr>
<td>1925</td>
<td>Murrumbidgee (Gundagai/Nangus)</td>
<td>NSW</td>
<td>8</td>
<td>252</td>
</tr>
<tr>
<td>1900</td>
<td>Hawkesbury</td>
<td>NSW</td>
<td>1</td>
<td>140</td>
</tr>
</tbody>
</table>
Flood

Maximum Loss

- $10 billion (assuming current market treatment of flood related loss)

RDS Locations

- Brisbane & SE Queensland
- Hawkesbury/ Nepean
- Georges River
- Hunter/ Newcastle
## Top ICA Events (1967-2012)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>State</th>
<th>Homes destroyed</th>
<th>Max wind km/h</th>
<th>Rescaled Insured Loss ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>Newcastle/Hunter ‘Severe Storm’</td>
<td>NSW</td>
<td>?</td>
<td>?</td>
<td>1,844</td>
</tr>
<tr>
<td>2011</td>
<td>Melbourne Christmas Day</td>
<td>Vic</td>
<td>?</td>
<td>?</td>
<td>754</td>
</tr>
<tr>
<td>1991</td>
<td>Sydney</td>
<td>NSW</td>
<td>580</td>
<td>230</td>
<td>556</td>
</tr>
<tr>
<td>2011</td>
<td>Melbourne ‘Severe Storms’</td>
<td>Vic</td>
<td>?</td>
<td>?</td>
<td>463</td>
</tr>
<tr>
<td>2008</td>
<td>Brisbane</td>
<td>QLD</td>
<td>?</td>
<td>?</td>
<td>376</td>
</tr>
</tbody>
</table>

## Other Significant Events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>State</th>
<th>Homes destroyed/damaged</th>
<th>Maximum wind km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>Ungarie</td>
<td>NSW</td>
<td>79/70</td>
<td>144</td>
</tr>
<tr>
<td>1949</td>
<td>Sydney</td>
<td>NSW</td>
<td>60/200</td>
<td>152</td>
</tr>
</tbody>
</table>
**Storm**

**Maximum Loss**
- $6 billion (impact on multiple locations possible from one “event”)

**RDS Locations**
- Sydney (southwest through north)
- Melbourne
- Brisbane
- NE Queensland
# Top ICA Events (1967-2012)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>State</th>
<th>Maximum hail size (cm)</th>
<th>Homes destroyed</th>
<th>Rescaled Insured Loss ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr-99</td>
<td>Sydney</td>
<td>NSW</td>
<td>7</td>
<td>?</td>
<td>4,548</td>
</tr>
<tr>
<td>Jan-85</td>
<td>Brisbane</td>
<td>QLD</td>
<td>7</td>
<td>?</td>
<td>2,124</td>
</tr>
<tr>
<td>1990</td>
<td>Sydney</td>
<td>NSW</td>
<td>8</td>
<td>1,450</td>
<td>1,373</td>
</tr>
<tr>
<td>Mar-10</td>
<td>Melbourne</td>
<td>Vic</td>
<td>10</td>
<td>?</td>
<td>1,228</td>
</tr>
<tr>
<td>2010</td>
<td>Perth</td>
<td>WA</td>
<td>5</td>
<td>?</td>
<td>1,155</td>
</tr>
</tbody>
</table>

# Other Significant Events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>State</th>
<th>Maximum hail size (cm)</th>
<th>Homes destroyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>Sydney</td>
<td>NSW</td>
<td>4.4</td>
<td>240</td>
</tr>
<tr>
<td>Dec-80</td>
<td>Brisbane (Brighton)</td>
<td>QLD</td>
<td>6.3</td>
<td>500</td>
</tr>
</tbody>
</table>
Hail

**Maximum Loss**
- $10 billion (super-cells could affect multiple areas in one event)

**RDS Locations**
- Sydney north west
- Sydney south east
- Brisbane
- Melbourne
### Industry Loss (AUD)

<table>
<thead>
<tr>
<th>Return Period (Years)</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$4,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$6,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$8,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$10,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$12,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$14,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$16,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$18,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$20,000m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Return Period (Years)

- Bushfire
- Storm
- Flood
- Hail
- Cyclone
- Earthquake

### General Insurance Seminar

**Tides of Change**

12-13 November 2012 - Sofitel Sydney Wentworth

**All Perils**

1. Develop insurance industry Probable Maximum Loss (PML) curves by peril
2. Determine all perils industry PMLs
3. Define scenarios for each peril to demonstrate individual and all perils losses at the 1-in-100 and 1-in-200 year levels
4. Apply scenarios to insurance portfolios to estimate RDS losses
Loss Matrix

<table>
<thead>
<tr>
<th></th>
<th>By peril 1 in 100</th>
<th>By peril 1 in 200</th>
<th>All perils 1 in 100</th>
<th>All perils 1 in 200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclone</td>
<td>3.5</td>
<td>6.5</td>
<td>8.8</td>
<td>13.5</td>
</tr>
<tr>
<td>Earthquake</td>
<td>4.6</td>
<td>9.8</td>
<td>8.8</td>
<td>13.5</td>
</tr>
<tr>
<td>Bushfire</td>
<td>3.0</td>
<td>3.3</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Flood</td>
<td>7.0</td>
<td>7.5</td>
<td>8.8</td>
<td>13.5</td>
</tr>
<tr>
<td>Storm</td>
<td>2.9</td>
<td>3.5</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Hail</td>
<td>7.0</td>
<td>8.0</td>
<td>8.8</td>
<td>13.5</td>
</tr>
</tbody>
</table>

1. Develop insurance industry Probable Maximum Loss (PML) curves by peril
2. Determine all perils industry PMLs
3. Define scenarios for each peril to demonstrate individual and all perils losses at the 1-in-100 and 1-in-200 year levels
4. Apply scenarios to insurance portfolios to estimate RDS losses
### Methodology

<table>
<thead>
<tr>
<th>Postcode</th>
<th>Exposure</th>
<th>% Loss</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4064</td>
<td>2,649m</td>
<td>2.3%</td>
<td>59m</td>
</tr>
<tr>
<td>4065</td>
<td>2,051m</td>
<td>2.3%</td>
<td>47m</td>
</tr>
<tr>
<td>4066</td>
<td>4,089m</td>
<td>2.2%</td>
<td>91m</td>
</tr>
<tr>
<td>4067</td>
<td>1,565m</td>
<td>1.5%</td>
<td>24m</td>
</tr>
<tr>
<td>4068</td>
<td>5,371m</td>
<td>1.5%</td>
<td>83m</td>
</tr>
<tr>
<td>4069</td>
<td>7,223m</td>
<td>1.8%</td>
<td>134m</td>
</tr>
<tr>
<td>4070</td>
<td>2,872m</td>
<td>1.4%</td>
<td>40m</td>
</tr>
<tr>
<td>4072</td>
<td>35m</td>
<td>1.5%</td>
<td>1m</td>
</tr>
<tr>
<td>4073</td>
<td>2,348m</td>
<td>1.2%</td>
<td>28m</td>
</tr>
<tr>
<td>4074</td>
<td>5,721m</td>
<td>1.3%</td>
<td>73m</td>
</tr>
</tbody>
</table>

1. Develop insurance industry Probable Maximum Loss (PML) curves by peril
2. Determine all perils industry PMLs
3. Define scenarios for each peril to demonstrate individual and all perils losses at the 1-in-100 and 1-in-200 year levels
4. Apply scenarios to insurance portfolios to estimate RDS losses
RDS01 - Cyclone $13.5b
RDS02 - Cyclone $8.8b
RDS05 - Earthquake $13.5b
RDS13 - Flood $13.5b
Validation against cat model loss
Sample insurer A

- Larger market share in Queensland and Victoria
Sample insurer B

- Larger market share in New South Wales, ACT and South Australia
Sample insurer C

- Larger market share in Western Australia
Pros and Cons

✓ Gives a quick answer
✓ Easily understood
✓ Numbers match for diverse companies
✓ Can compare portfolios/insurers

✗ Less useful for insurers with concentrated exposures
✗ No account of portfolio complexities
Other Methods

• Pure concentration management
  – Too conservative unless considering most severe events

• Loss multiple by ICA zone
  – Used prior to cat models
  – Seen as inferior
  – Could make a comeback as another in the suite of multi-models
Waves, Wind and Water: Weather perils and insurance
Dmitry Gorelik - 16th GI Seminar 2008

**ENSO by Peril – Event Counts**

- **Proportion of Losses**
  - Bushfire: 38%
  - Cyclone: 40%
  - Flood: 69%
  - Hail: 46%
  - Storm: 42%
  - Storm/Hail/Flood: 47%

- **La Niña**
  - Bushfire: 63%
  - Cyclone: 20%
  - Flood: 15%
  - Hail: 32%
  - Storm: 38%
  - Storm/Hail/Flood: 32%

- **Neutral**
  - Bushfire: 40%
  - Cyclone: 69%
  - Flood: 15%
  - Hail: 46%
  - Storm: 42%
  - Storm/Hail/Flood: 47%

- **El Niño**
  - Bushfire: 20%
  - Cyclone: 15%
  - Flood: 15%
  - Hail: 22%
  - Storm: 20%
  - Storm/Hail/Flood: 20%

- Size of the event can skew the representation of losses over time
- Frequency of losses shows that:
  - Bushfires tend to occur during the El Niño Phase
  - Cyclones during Neutral and La Nina
  - Storm/Hail Flood during Neutral and El Niño phases
Bushfire - El Nino Southern Oscillation

The graph shows the relationship between the Return Period (Years) and PML (AUD $m) for different El Nino conditions:

- **El Nino** (red line)
- **Neutral** (blue line)
- **La Nino** (green line)

The graph illustrates how the PML increases significantly with increasing return periods, with El Nino conditions generally resulting in higher PML values compared to Neutral and La Nino conditions.
Future Enhancements

• More events
• Split by Residential/ Commercial/ Industrial/ Motor
• “Smear” events to ensure stability
• Include multi-event clusters (e.g. bushfire)
• Expand to include New Zealand
Conclusions

• An RDS approach can be used to determine PMLs at specific return periods given adequate scenario definition
• Care must be taken to consider shortcomings of this approach, especially with less diversified portfolios
• This method provides a useful additional measure for quantifying catastrophe concentration risk
Contact

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Realistic Disaster Scenarios v1.0

FreeCatModel.com