Comparing volcanic risk at Volcán de Fuego and Cerro Quemado, Guatemala.

PhD research proposal by Rüdiger Escobar Wolf.
What do I want to investigate?

“The greatest losses generally occur at volcanoes that erupt infrequently where people are not accustomed to dealing with them.”


Could this be a testable hypothesis?
Maybe looking at two typical volcanoes for each case:

Goal:

To measure the risk associated to the eruptive activity at Volcán de Fuego and Cerro Quemado in a commeasurable way and make the comparison.
Need a definition of risk and a way to measure it...

A working definition of risk:
The probability that someone will face a measurable loss (value) due to a specific cause (hazard) in a given time and space frame.
Event trees and probabilities:

A conceptual framework to develop a model that measures and “explains” the risk.
- Uncertain future and multiple possible outcomes.
- Incorporate information from various sources and integrate different approaches.
Newhall and Hoblitt, 2002 (Bull Volc 64:3-20)

Note: Any branch that terminates with “Clone” is identical to the subsequent central branch. For example, in the Magnitude column, the VEI-4 and VEI-2 Clones are identical to the central VEI3 branch.
An example for Volcán de Fuego:

1. Annual eruption probability (since 1524): 0.145
2. Probability for different VEI’s

- VEI 2 = 0.76; from historic record.
- VEI 3-4 = 0.22; from historic record.
- VEI 5 = 0.02; by analogy of 18 volcanoes with similar characteristics that have had activity during the Holocene.
3. Probability of different phenomena:

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3 to 4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tephra*</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PDC</td>
<td>0.5</td>
<td>0.95</td>
<td>1</td>
</tr>
<tr>
<td>Lahar</td>
<td>0.5</td>
<td>0.95</td>
<td>1</td>
</tr>
</tbody>
</table>

*More than 20 cm thickness
## 4. Direction

<table>
<thead>
<tr>
<th>Direction</th>
<th>Tephra*</th>
<th>PCD**</th>
<th>Lahar</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>0.17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>East</td>
<td>0.31</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>West</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>South</td>
<td>0.19</td>
<td>0.33</td>
<td>0.33</td>
</tr>
</tbody>
</table>

* From Mercado et al 1988
** assumed
5. Distance

<table>
<thead>
<tr>
<th>Distance</th>
<th>Tephra VEI 2</th>
<th>Tephra VEI 3-4</th>
<th>Tephra VEI 5</th>
<th>PDC VEI 2</th>
<th>PDC VEI 3-4</th>
<th>PDC VEI 5</th>
<th>Lahar VEI 2</th>
<th>Lahar VEI 3-4</th>
<th>Lahar VEI 5</th>
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</thead>
<tbody>
<tr>
<td>0 to 5</td>
<td>0</td>
<td>0.6</td>
<td>0.9</td>
<td>0.8</td>
<td>0.9</td>
<td>0.95</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5 to 10</td>
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<td>0.75</td>
<td>0.25</td>
<td>0.4</td>
<td>0.55</td>
<td>0.5</td>
<td>0.8</td>
<td>1</td>
</tr>
<tr>
<td>10 to 15</td>
<td>0</td>
<td>0.4</td>
<td>0.7</td>
<td>0.05</td>
<td>0.1</td>
<td>0.35</td>
<td>0.1</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>15 to 20</td>
<td>0</td>
<td>0.3</td>
<td>0.65</td>
<td>0</td>
<td>0.1</td>
<td>0.25</td>
<td>0</td>
<td>0.2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

From Newhall and Hoblitt, 2002; Iverson et al 1998 or assumed.
6 and 7. Exposure and vulnerability

- Probability of normal occupancy (based on occupancy and land use criteria): 1.
- Probability of an early warning failure (based on personal opinion): 0.66.
- Probability of death:
  - From tephra accumulation of 20 cm: 0.1.
  - By PDC’s: 0.95
  - By lahars: 0.95
Results:

Population at risk due to volcanic activity at Fuego.
It looks easy...

- Defining the structure and calculating the probabilities is trivial.

- Assigning probabilities to the nodes is not!
Naïve approach vs. more elaborated estimates:

A case for flow phenomena...
C14 age: 1498-1698 AD. Could it be the 1581 or 1717 AD eruption?
**R vs. Slope**

- **Slope (fraction)** vs. **R (m)**
- Data points for Channel and Over bank

**Change in R vs. change in Slope**

- **Slope change (fraction)** vs. **R Change (m)**
- Data points for Channel and Over bank

**Area Vs. H/L**

- **H/L** vs. **Area (km2)**
- Data points for Channel and Over bank

Other data from Calder et. al. 1999.
Complexity of phenomena at other nodes...

- Tephra fall
- Structural vulnerability
- And specially the case of exposure and its link to *early warning effectiveness*, since it is here where intervention most probably will (and can) happen.
Improving estimates of probability at nodes and modeling the associated processes...

Marzocchi et al, 2004 (JGR, 109, B11201) proposed a Bayesian approach to assign probabilities to the nodes.

Hincks, 2006 (MS Thesis, U. Bristol) expanded the analysis to include the physical vulnerability and the forecasting capacities of an early warning system.

The probability of people actually leaving the area hasn’t been included in such analysis, can that be done?
The approach I will follow:

- Probability tree using a Bayesian approach.
- Improve probability estimates by the use of models (e.g. using numerical modeling codes like ASHFALL by T. Hurst and applying the method developed by C. Connor).
- Not a blind modeler... need to constrain models with field and other data.
- Can I “model” peoples response to a warning?
Criteria to consider and “challenges to face”:

• Intellectual merit? Original and creative? Builds on previous efforts to develop the method...

• Relevance? Can have an impact on risk assessment methods.

• Feasible and credible? Are the methods appropriated?
A working plan?

• What methods (specially in the social part)?

• What resources?

• What partners / advisors (cooperation with Guatemalan institutions)?

• What funding?
Thanks!

Questions?