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Discussions

Interactive comment on “Design of parametric risk transfer solutions for volcanic eruptions: an application to Japanese volcanoes” *by* Delioma Oramas-Dorta et al.

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We thank Referee #2 for their helpful feedback; please find our replies below:

1. Some of the arguments in the introduction should be more clearly supported by evidence from the literature. For example, on line 100-102, provide literature to support the statement about the proper choice of parameters.

Authors: Further background and references on this topic are provided below:

“Properly chosen parameters that are easy to measure transparently and with accuracy can provide parametric cat bonds with a speed of payment unparalleled in the domain of insurance. The choice of parameters has evolved since the 1990’s when these tools first appeared, resulting in different choices of design. For instance, in the case of earthquake two types of solutions have been used in the market successfully: first generation CAT-in-a-box triggers, and second-generation parametric indices (Franco 2010). The first type is based on the magnitude, epicenter location, and focal depth of the event, whereas the second are based on geographically distributed earthquake parameters such as ground motions. Second-generation are considered to be superior to first generation triggers owing to better correlation between the distributed parameters and resulting losses (Franco 2010, Goda 2013).

2. Wet version: on lines 165-171, the authors describe how they developed the “wet version” of the scenarios. They refer to a paper by Macedonio and Costa (2012) for the approach. Whilst this is fine, a short overview of this methods should also be summarized in this paper to give the reader an overall understanding of how it works (referring the reader to the paper for the details of course).

Authors: We propose to re-write the paragraph as follows:

“The methodology used to create “wet” footprints follows that described by Macedonio and Costa, 2012, whereby deposited ash fall increases its weight up to the point it becomes saturated with rainfall water, assuming a density of 1000 Kg/m3 and a total porosity of 60% for deposited ash fall from Mt. Fuji. Following Macedonio and Costa, 2012, we assume that all pores and interstices of the deposit are filled with water (water saturation), if enough water is available from a specific rainfall event. Rainfall data were supplied by JBA Risk Management in the form of 10,000 years of simulated daily precipitation that incorporates tropical cyclone and non-tropical cyclone precipitation.”

3. Vulnerability functions: Figure 2 gives a clear example of two vulnerability curves. However, for reproducibility, have the authors considered providing all curves, for example in a supplementary dataset?

Authors: The source of the damage functions has been specified and referenced in the paper (GAR15 Regional Vulnerability Functions report by Maqsood et al., 2015), which contains a comprehensive Annex with graphs for all the ash fall damage functions by construction type, building rise and roof pitch.

4. BE module: please provide more information on how this is done – for example, how does the assignment on the probabilistic basis work?

Authors: We propose to add the following text from line 219 onwards:

“To illustrate how the BE works, let us take an example of a Residential building in a Postal Code in Kanagawa prefecture. If that is all the information we know about this asset, the BE module will use the weights corresponding to Residential buildings in that postal code to assign a specific location within the postal code and a set of characteristics (construction type, etc.) to this Residential building (please see Table 2 for a list of possible Residential building types). Such assignation is probabilistic in the sense that a distribution of likely locations and characteristics will be generated for each risk, through iterative sampling based on those weights. Such distribution will eventually be propagated to the loss calculation part of the model, in order to produce a final loss distribution for this building.”

5. Parts of the current conclusion would better split out into a separate discussion section. In particular, the parts discussing the limitations and challenges, as well as applicability elsewhere. This would give the opportunity to slightly expand these aspects, with reference to key literature. For example, given the topic of the special issue, one of two extra paragraphs describing key challenges for upscaling globally would be useful (there is some reasoning along this line but it is very short). The conclusion could then be kept shorter and more succinct.

Authors: We propose to re-write as follows (additional reference have been added at the end):

Discussion

We present a novel methodology to parameterize financial risk transfer instruments for explosive, tephra fall- producing volcanic eruptions. The design of the parametric product relies on physical parameters relating to explosive volcanic eruptions; namely maximum observed height of the eruptive column and the prevalent direction of dispersal of the associated ash plume.

We take as a case study Mount Fuji in Japan, the largest and closest active volcano to the populous Tokyo metropolitan area and the heavily industrialized Kanagawa prefecture (Yamamoto & Nakada, 2015). In Japan, the JMA reports height of the eruptive column and the predominant direction of ash dispersal as part of the “Observation Reports on Eruption” that are released for any erupting volcano on a near-real time basis. The design of the parametric risk transfer for our case study relies on Guy Carpenter’s fully probabilistic model for volcanic eruptions potentially affecting Tokyo and Kanagawa prefectures, which includes 10,000 simulated volcanic ash fall events arising from explosive eruptions of different sizes at Mount Fuji.

For the parametric design, we focused on explosive eruptions producing significant tephra loads capable of generating property damages (these are the type of eruptive events considered by the volcano risk model), and took as an example a “portfolio” of residential properties representing the existing residential building stock in the Tokyo and Kanagawa prefectures. These could be severely affected by a significant eruption from Mount Fuji- the last Fuji eruption in year 1707 is a good example - thus potentially generating a financial burden for the regional and/or or national Governments.

We designed a multi-layer trigger assuming that a policy holder might be interested in covering all losses exceeding 30 Billion JPY, with a coverage releasing two possible payment levels of 100 and 300 Billion JPY provided the appropriate trigger conditions of eruptive column height and predominant plume direction are met (Table 6). This product would provide a policy holder such as a regional Government a quick way to access cash to help repair damages incurred by dwellings as a consequence of a major volcanic eruption, or provide the necessary cash flow to underwriters in these

Prefectures (insurance cover for volcanic eruptions is included as part of the standard earthquake policies in Japan).

There are several features of the design presented that make it potentially applicable to other volcanic settings where explosive volcanism is typical. In particular, the choice of eruption-related parameters (height of eruptive column and preferential direction of dispersal of ash fall) means that no special monitoring equipment is needed for recordings. Implementation should be straight forward in countries with established volcano observatories, however less than half of the potentially active volcanoes are monitored with ground-based sensors, and even less are considered well-monitored (Brown et al., 2015). This aspect poses a challenge to the global implementation of such product. In this sense, it would be interesting to explore and expand monitoring solutions like satellite-based remote sensing to report both column height and preferential direction of ash fall dispersal on a near real time basis. An example of such system is HOTVOLC, developed and managed by the Observatoire de Physique du Globe de Clermont-Ferrand (OPGC) and currently operative for 50 volcanoes worldwide (Guéhenneux et al., 2015; https://hotvolc.opgc.fr). HOTVOLC reports several eruption-related parameters on a real time basis, including ash plume altitude. On the other hand, it is important that an official, reputable national or regional agency reports such observations in a reliable and timely manner, which could be national volcanological or meteorological agencies, global organizations such as the World Organization of Volcano Observatories (WOVO.org), or perhaps a bespoke global organization akin to Volcanic Ash Advisory Centers (https://www.icao.int/Pages/default.aspx).

The other important requisite that needs to be in place for the successful design of an equivalent parametric product elsewhere is the availability of a suitable volcano risk model for the area of interest. Such model must be able to generate stochastic loss outputs associated to ash fall-producing eruptions, encompassing the range of all possible eruptive events of interest, and incorporating information relating to plume height and the predominant direction of ash fall dispersal for each event. In an insurance

context availability of these models is still rare, since their development requires from a non-negligible investment of time and resources, and volcanic eruptions are generally considered as a “secondary peril” by the insurance industry (e.g. Blong et al., 2017).

Further work on the design of volcano-related parametric risk transfer products may relate to different aspects. On one hand, and also considering ash fall-producing volcanic eruptions, the design may be extended to consider other types of damages such as those to crops and livestock, costs arising from ash fall clean up and disposal in urban areas and roads, Business Interruption costs arising from air traffic disruption, airport closures and disruption of critical infrastructures including transportation networks, electricity, water supplies and telecommunications, etc. (Wilson et al., 2012). For any of these types of losses, specific ash fall vulnerability functions must be incorporated in the fully probabilistic volcano model considered. The parametric design presented in this paper could be adapted to coverage of these types of losses, provided a strong correlation was also found between eruptive column height and main direction of ash dispersal and modelled losses.

On the other hand, despite ash fall is the volcanic peril with the largest potential of causing wide spread losses (since it is by far the most widely distributed eruptive product), there are other volcanic perils that have a large destructive potential, albeit with a more constrained spatial reach. These include lava flows, pyroclastic density currents, lahars, volcano flank collapses and ballistic blocks (e.g. Loughlin et al., 2015). Design of parametric transfer products for these volcano hazards would entail a rather different approach; concerning both the modelling of losses (starting with the incorporation of these specific hazard events to the fully probabilistic volcano model), to the selection and monitoring of hazard-related trigger parameters.

Conclusions

The design of the parametric risk transfer product described in this work displays features, such as its reliance on easily obtainable, observable physical parameters relating to explosive volcanic eruptions, which makes it an attractive option for implementation on a regional or global basis. We believe that global volcano monitoring tools and platforms already in place could be adapted to this end. Notwithstanding the scarcity of fully probabilistic volcano risk models suitable for this purpose, the increased collaboration between academic experts and the insurance industry can bring all the necessary elements together for the creation of such models, as it has been in the case presented in this paper. The availability of open-source hazard simulation models such as tephra2 and of global open databases (e.g. wind data, eruptive data, etc.) means that the ingredients needed for development are pretty much available on a world-wide basis. Scaling up such approach in order to model a significantly larger number of volcanoes than presented in this paper is currently being looked into, with promising preliminary results.

These products could be of interest to a number of organizations, including regional and national Governments, but also insurers and other economic sectors. Increased interest in parametric risk transfer products from the insurance industry and capital markets is helping build momentum for the development of risk models of “non- traditional” perils such as volcanic eruptions, and the design of associated risk transfer mechanisms.

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