RIESGOS

MULTI-RISK ANALYSIS AND INFORMATION SYSTEM COMPONENTS FOR THE ANDES REGION

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# *Scenario- based multi- risk assessment on exposed buildings to volcanic cascading hazards*

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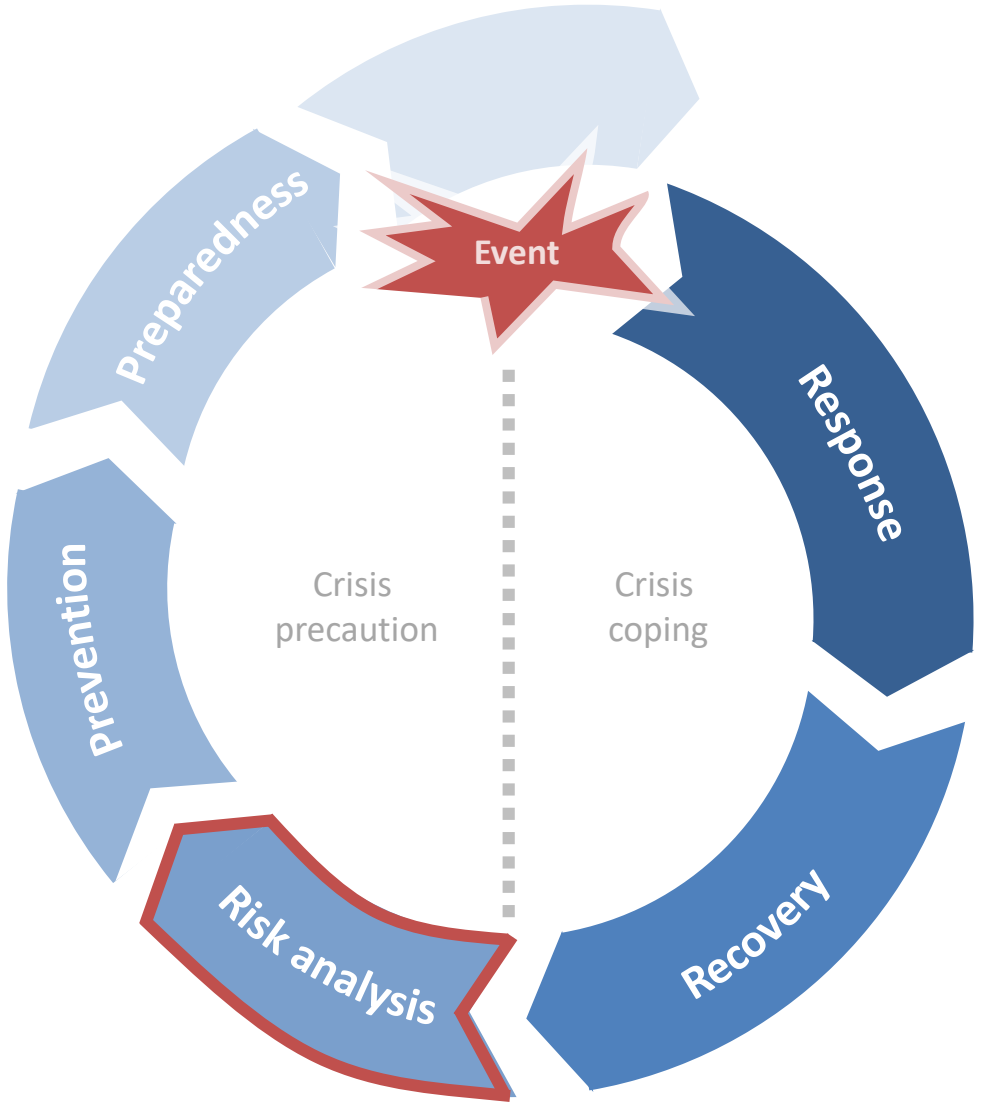
# Multi- risk assessment: a global motivation

The Sendai Framework for Disaster Risk reduction (2015-2030) emphasizes the need for improved understanding of disaster risk in all its dimensions of *exposure, vulnerability, and hazard characteristics*, which streamlines the relevance of being able to construct **a holistic but rigorous multi-hazard- risk assessment framework.**

From single-hazard to **multi-hazard risk assessment**, including exposure and dynamic vulnerability, and progressing towards the analysis of cascading effects**: The Cascading Volcanic hazards example**

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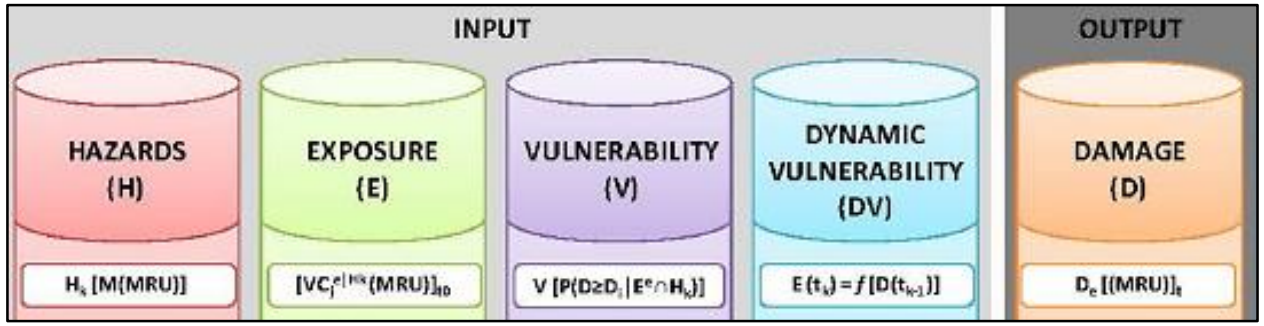
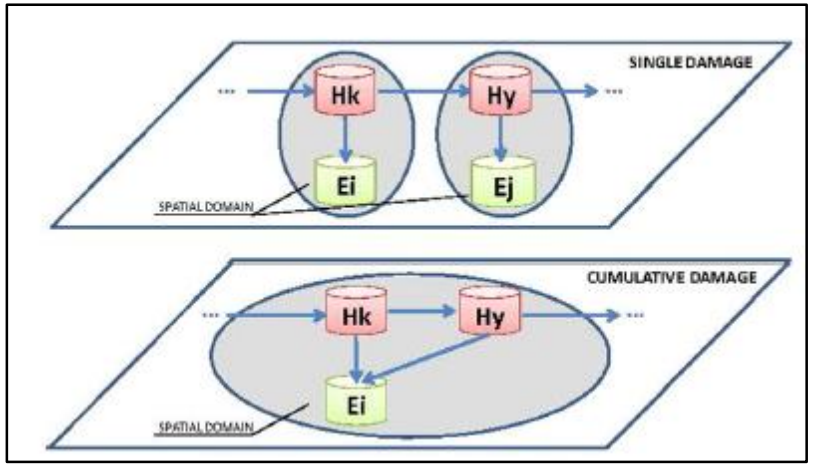
# Multi- risk assessment:

## *General framework on Dynamic physical vulnerability*

*Contributing to the state of the art development:*
*We are building upon initially proposed theoretical ideas*

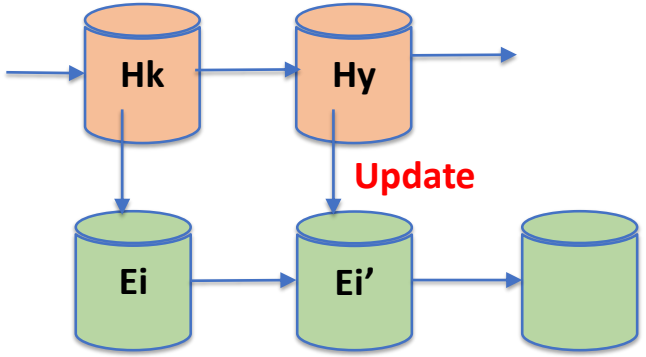



*Zuccaro et al, 2018*

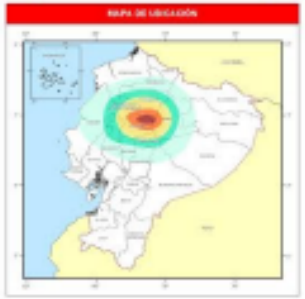
The multi- risk assessment should consider the possible hazards and **vulnerability interactions** over the very same exposed elements.

**Multi-risk assessment framework** comprises both multi-hazard and multi-vulnerability concepts (e.g. Carpignano et al., 2009; Garcia-Aristizabal and Marzocchi, 2012a, 2012b; Gallina et al, 2016). Under this scope, the multi- risk assessment should consider the possible hazards and **vulnerability interactions** over the very same exposed elements.



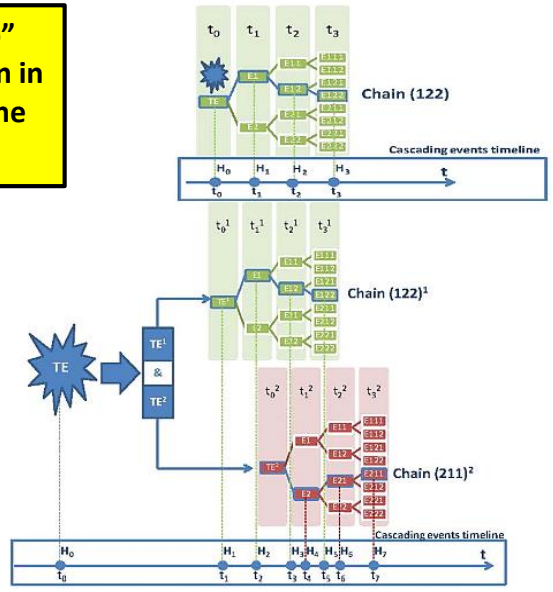

*(This work)*

# Multi-risk Scenario approach: *Ash-Fall- Lahar example (Cotopaxi volcano)*



**For simplicity and as a proof of concept, the two phenomena (ash-fall and lahar) originated from the Cotopaxi volcano (Ecuador) are assumed as cascading hazards. No compound ones.**

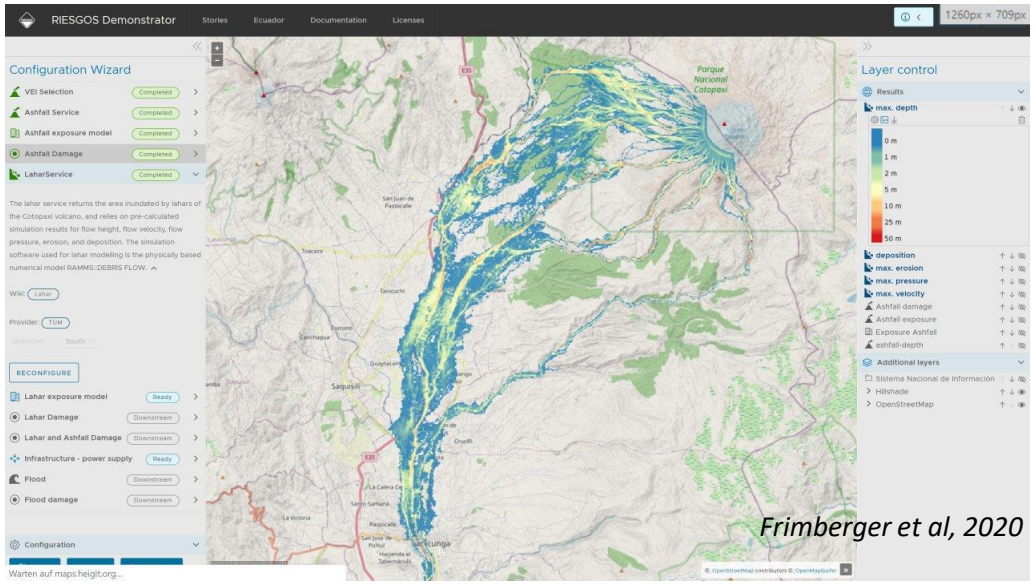
**"Scenario" construction in terms of the VEI**




**Coupled multi-hazard scenarios**

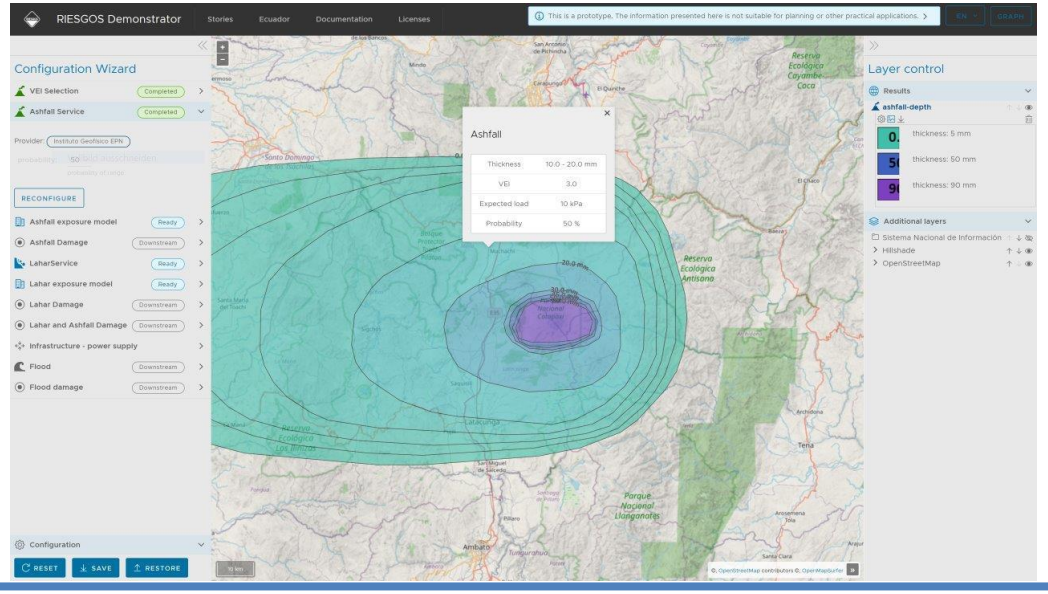

What about every hazard intensity measure geographical distribution?

**Lahar**




*Frimberger et al, 2020*

**Ash-Fall**

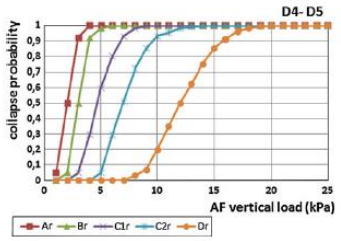


# Constructing a Dynamic Vulnerability Framework:

## *Collecting Vulnerability functions for Ash-Fall- Lahars*

### Ash-Fall

| Author | Type of Hazardous event | Geographical area the fragilities were derived | Number of damage states | Predominant building material | Intensity measure (I.M) | [ Physical unit ] |
|---|---|---|---|---|---|---|
| Zuccaro and De Gregorio., 2013 | Ash Falls | Mount Vesuvius | 1 (Probability of Failure) | Wood RC, Steel | A.F Vertical Load | kPa |
| Spence et al., 2005 | Ash Falls | Mount Vesuvius, Teide, Soufriere, Francesao Miguel | 1 (Probability of Failure) | Wood, RC, Steel | Tephra fall Load | kPa |
| Torres–Corredor et al, 2017* | Ash Falls | Galeras Volcano | 1 (Probability of Failure) | Wood, RC, | | |

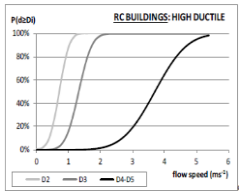



Zuccaroi et al., 2013

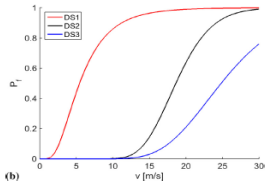
*Torres- Corredor et al, 2017 was further adapted to get 3 damage states and as proof of concept of the overall multi-state framework

### Lahar

| Author | Hazardous event | Number of damage states | Predominant building material | Building ductility level | Intensity measure (I.M) | [ Physical unit ] |
|---|---|---|---|---|---|---|
| Mavrouli et al., 2014 | Slow moving landslides and Lahars *(as proposed in Zuccaro and DeGregorio, 2013)* | 4 | RC | There is a strong "earthquake engineering" vision in other hazards failure conception… | Maximum Foundation Displacement | m |
| | Debris- Flow | 6 | RC | | Flow Speed | m/s |
| | Rockfalls | 4 | RC | | Diameter | M |
| Prieto et al., 2018 | Debris- Flow | 4 | URML | | Momentum Flux | (m^3/s^2) |
| Jenkins et al., 2015 | Lahars | 1 | Rubble stone and squared Block Masonry | | Impact Pressure | kPa |
| Parisi et al., 2016 | Debris- Flow | 3 | Infill wall | Weak | Flow velocity | m/s |
| | Debris- Flow | 3 | Infill wall | Medium | Flow velocity | m/s |
| | Debris- Flow | 3 | Infill wall | Strong | Flow velocity | m/s |

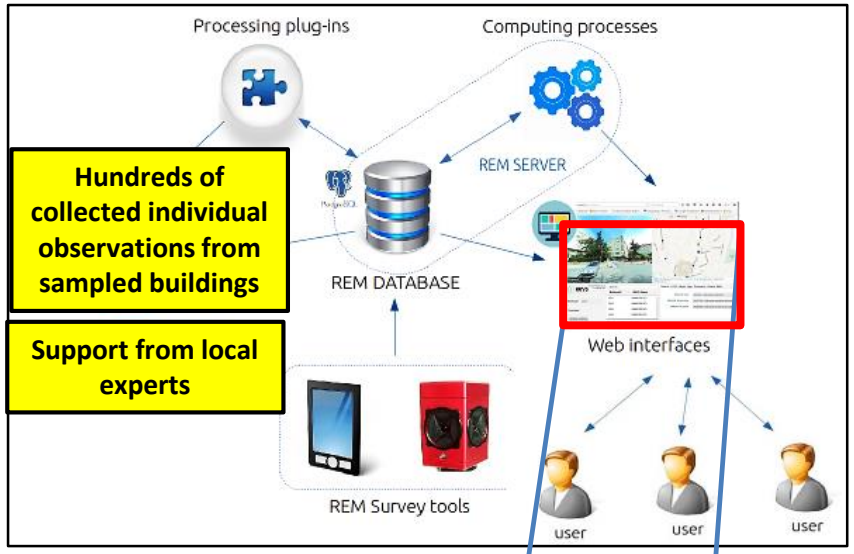



Movrouli et al., 2018



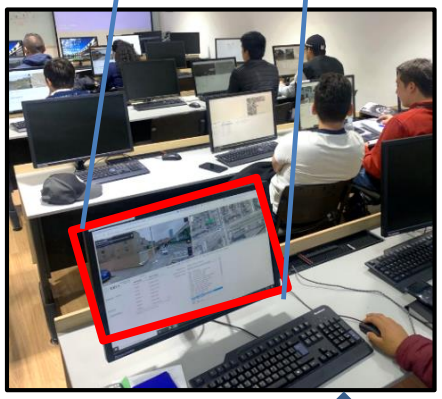

Parisi et al., 2016

# Identifying the plausibility of using "foreign" volcanic fragility functions




**Hundreds of collected individual observations from sampled buildings**

**Support from local experts**

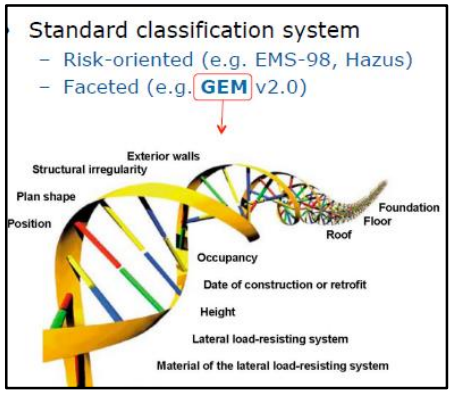


A comprehensive multi-hazard faceted building taxonomy able to address most of the building attributes driving the vulnerability with respect to different hazards

## *Rapid Remote Visual Screening with a Multi- hazard- building taxonomy*

Building's structural and non-structural properties on a global scale.

*(this work after Haas et al, 2016 and* (Pittore et al., 2017)




Seismic- oriented faceted GEM building taxonomy

Brzev *et al, 2013*

Are there any other controlling building attributes that may drive the building's vulnerability towards other hazards?

*e.g. Charvet et al, 2017*
*Blanco-Voigt, 2015*

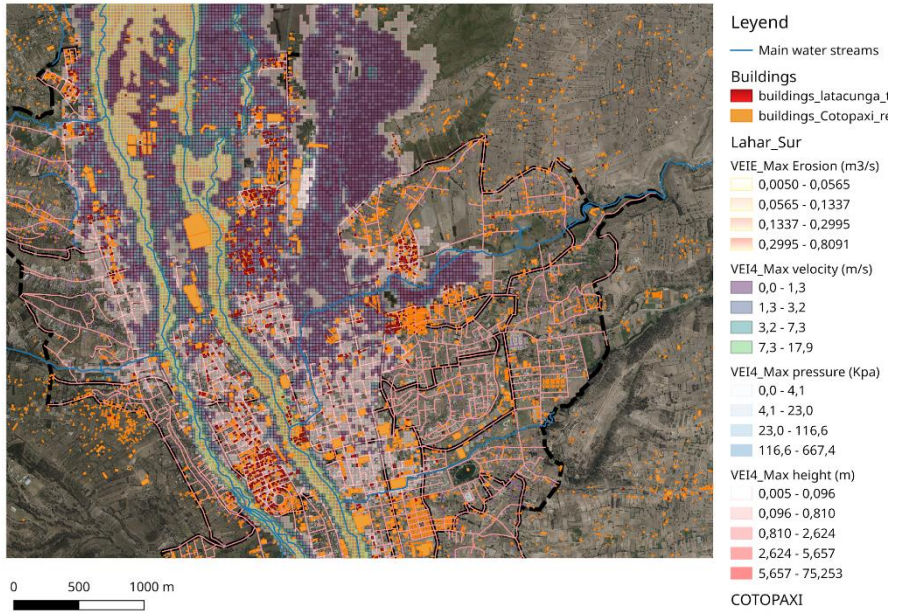
The RIESGOS Multi-hazard- faceted building taxonomy

GED4ALL

*Silva et al, 2018*
Brzev *et al, 2020*

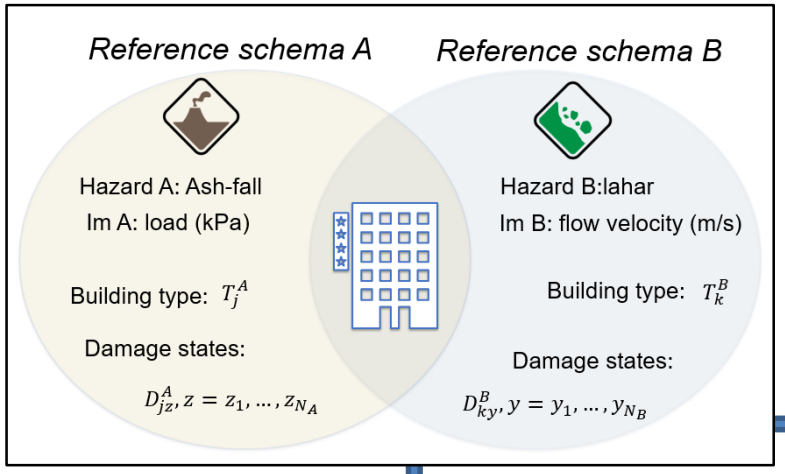
Lahar modelling outputs (I.M) for a VEI= 4 to constrain the building sampling!

**A wise- building sampling strategy as function of the hazard intensity is always advised.**

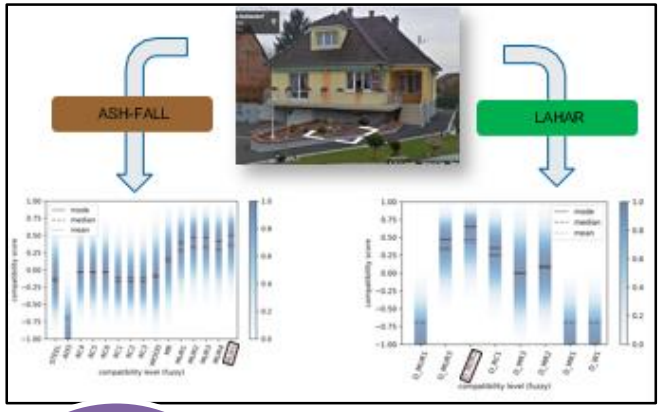


# Following the damage evolution in a volcanic multi- hazard- risk scenario

The hazard acting forces and intensities are different, but some of the exposed components remain the same.



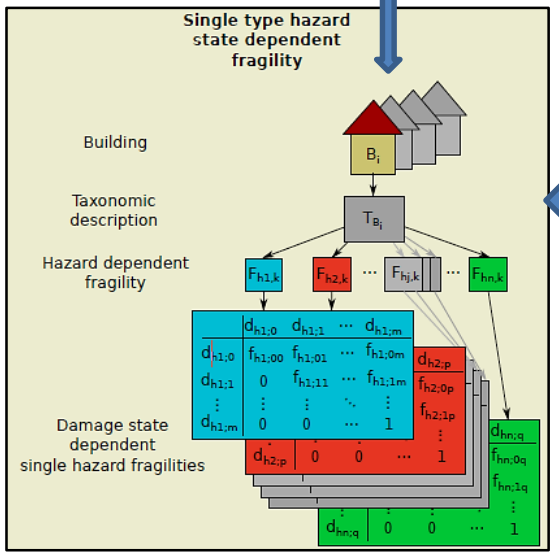

(this work)




(After Pittore et al, 2018)

A methodology to implement probabilistic mapping across different hazard-dependent building schemas and damage states

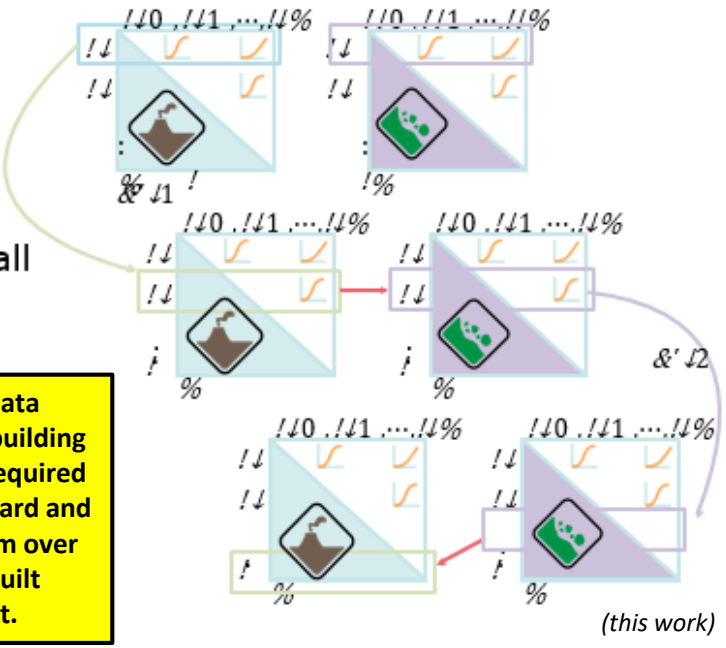
Mutually exclusive, collectively exhaustive (MECE) building classes per reference hazard with associated fragility functions




(this work)

DYNAMIC VULNERABILITY (DV)

A generalized description of the damage state of a building based on a set of low-level observable damage types

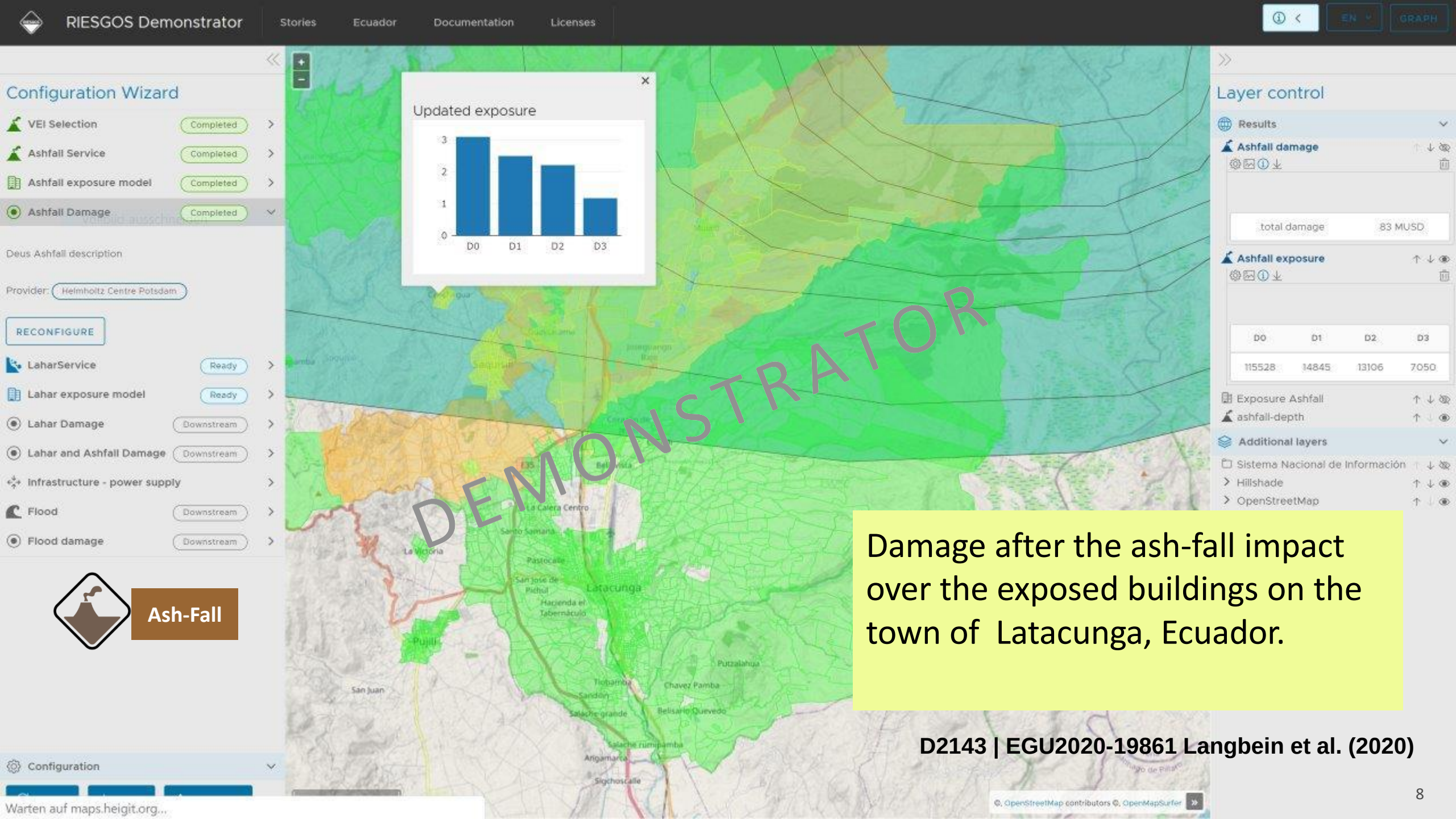


Ash-Fall

Lahar

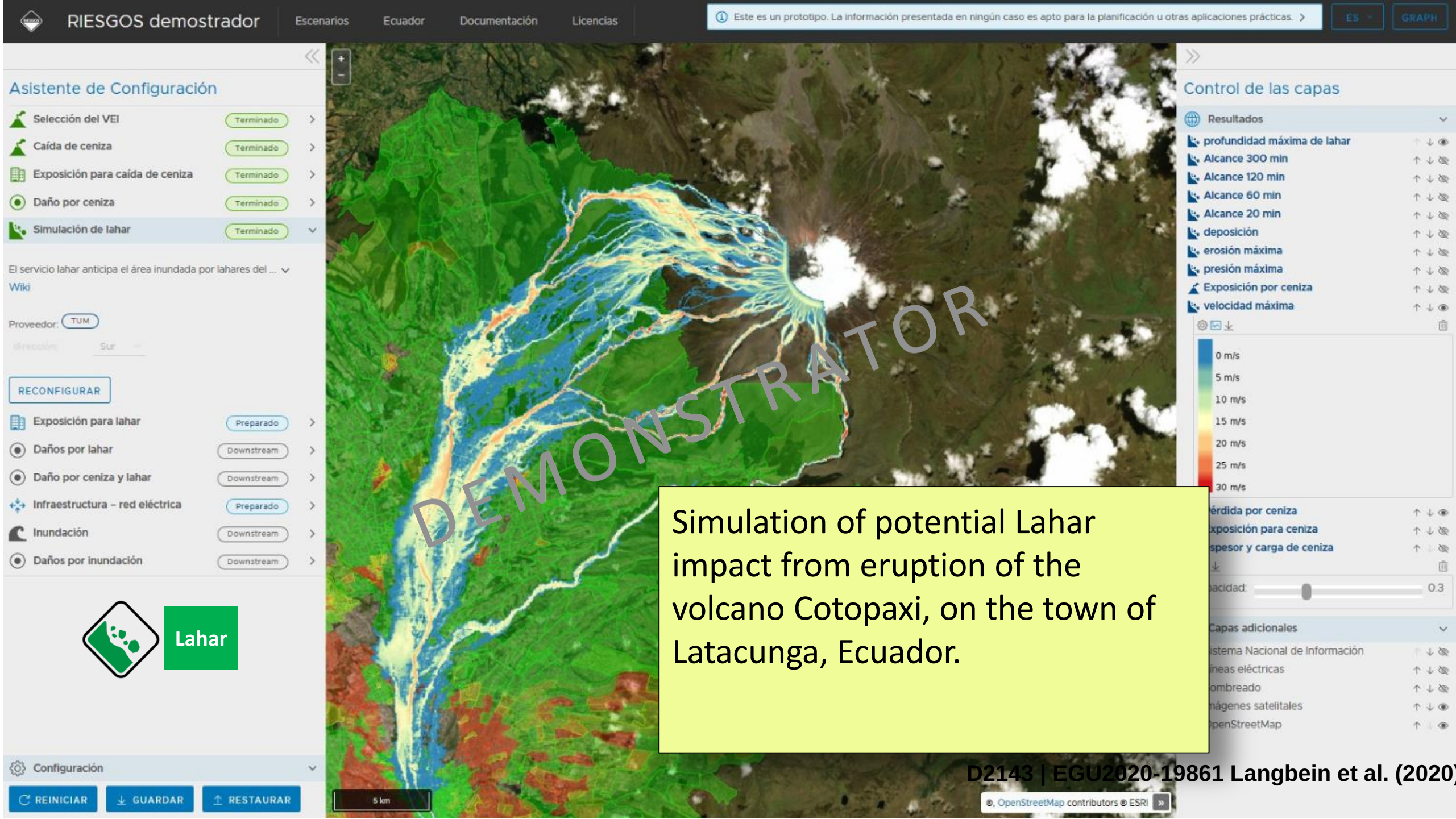
**Harmonized data collection at the building element level is required regardless the hazard and failure mechanism over the exposed built environment.**

(this work)




Damage after the ash-fall impact over the exposed buildings on the town of Latacunga, Ecuador.

**D2143 | EGU2020-19861 Langbein et al. (2020)**




Simulation of potential Lahar impact from eruption of the volcano Cotopaxi, on the town of Latacunga, Ecuador.

D2143 | EGU2020-19861 Langbein et al. (2020)

D2143 | EGU2020-19861 Langbein et al. (2020)

## Configuration Wizard

- VEI Selection — Completed
- Ashfall Service — Completed
- Ashfall exposure model — Completed
- Ashfall Damage — Completed
- LaharService — Completed
- Lahar exposure model — Completed
- Lahar Damage — Completed
- Lahar and Ashfall Damage — Completed

Deus Lahar + Ashfall description

Provider: Helmholtz Centre Potsdam

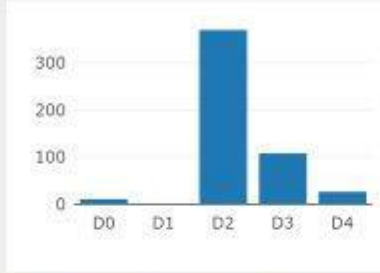
RECONFIGURE

- Infrastructure - power supply — Ready
- Flood — Downstream
- Flood damage — Downstream

Configuration

RESET | SAVE | RESTORE

Updated exposure




Ash-Fall

Lahar

Layer control

Results

Lahar and Ashfall Exposure

| D0 | D1 | D2 | D3 | D4 |
|---|---|---|---|---|
| 26756 | 0 | 95367 | 10872 | 17534 |

- Lahar and Ashfall Transition
- Lahar and Ashfall Damage
- max. depth
- Lahar exposure
- Lahar damage
- Exposure Lahar
- deposition
- max. erosion
- max. pressure
- max. velocity
- Ashfall damage
- Ashfall exposure
- Exposure Ashfall
- ashfall-depth

Additional layers

Cumulated damage after the ash-fall and lahar impact over the exposed buildings on the town of Latacunga, Ecuador.

# Some Remarks

- We have been able to set up a framework for volcanic- multi- hazard, multi- risk damage and multi- risk damage loss assessment. This method allows to consistently re-use existing single hazard fragility in a multi- risk framework.

- It is evident the urgent need of accurate local models and with multi-damage- state functions (not only probability of collapse, such as in most of the available as-fall fragility functions.

- A comprenhensive faceted multi-hazard- building taxonomy is a fundamental piece in this multi- hazard- risk framework. Its implementation to collect local observations over a selected building simple (through a wise- hazard-focus building sampling) has high relevance in order to constrain the innitial assumptions on the definition of mutually exclusive, collectively exhaustive (MECE) building classes.

- The general assumption of "intact" buildings for which the conventional single- hazard fragility functions are made is questioned and overcoming this aspect should be a general issue to be addressed by the Multi- hazard- community.

- The epistemic uncertainty in the building- portfolio exposure definition, and their link with the spacial hazard intensity distribution plays a fundamental role in a consistent multi- hazard-risk framework.

- Multi-risk vulnerability models have to consider the state dependency in order to model the accumulation of physical damage across a sequence of (different) natural events.

- A common framework across the different natural hazards- risk communities aiming for a harmonized damage- data collection at the building element level is required to constrain a common baseline in a multi- risk framework.

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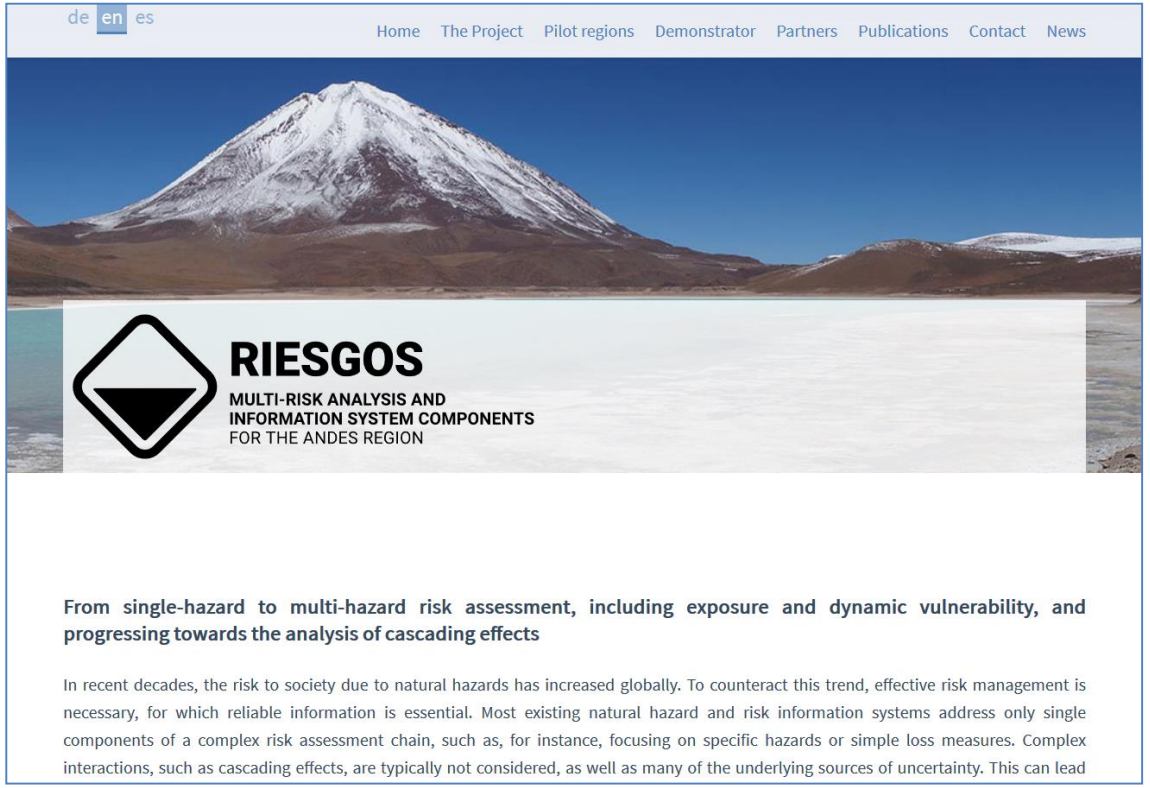
# RIESGOS – Further Information


DLR GFZ

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