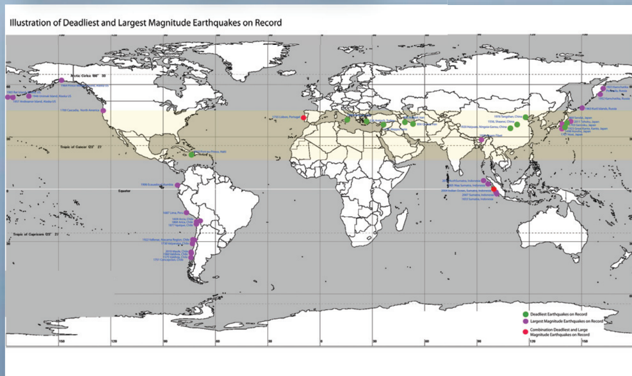
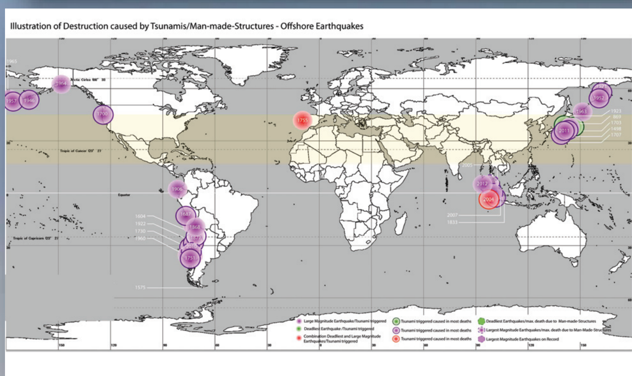
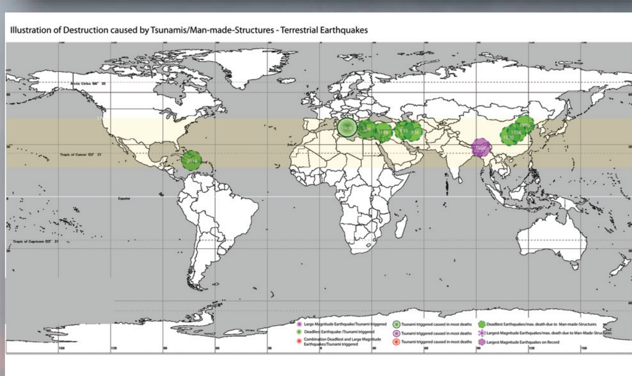
Earthquakes







Risk Perception and Management

Risk awareness and monitoring is highly uneven across the world, and this creates two kinds of problems. Firstly, potential hazards are much more closely monitored in wealthy countries than in the developing world. But the largest hazards are global in nature, and it is critical to get as much forewarning as possible to develop an effective response. The disasters and near-misses of the past show that adherence to scientific knowledge, particularly during the early warning phase, can reduce disasters. This suggests that a strong global monitoring system for geohazards is needed, not least to support the early detection of extreme hazards. Secondly, low risk awareness combined with poverty, corruption, and a lack of building codes and informed land use management creates the conditions to turn hazards into disasters throughout much of the developing world. Democratizing knowledge about extreme geohazards is very important in order to inform deliberations of disaster risks and community strategies that can reduce the disaster isk by increasing resilience and adaptive capacities without compromising the livelihood of communities.

The Extreme Hazards

Besides local and regional direct impacts, large volcano eruptions have the potential to impact climate, anthropogenic infrastructure and resource supplies on global scale. During the last 2,000 years several eruptions occurred (Table 1 and Figures 1 to 3), which today are associated with extreme disaster risk. The extreme earthquakes that occurred during the 2000 years (Table 2) have illustrated the distruction they can inflict (Figure 4), both directly and indirectly through tusnamis (Figure 5). The resulting disasters are amplified in areas with poor building infrastructure (Figure 6 and Table 3). The comparison of earthquakes and volcano eruptions shows that volcanos are the geohazards that can cause the most extreme disasters with global impacts.

The Need for a Volcano Monitoring System

The disaster caused today by a large eruption comparable to the most extreme ones experienced during the last 2,000 years could reach global scale and trigger many environmental, economic, and social consequences. A global volcano monitoring system is required as a basis for an early warning system. However, for some eruptions, lead times are extremely short and disaster risk reduction will require to reduce vulnerability of infrastructure, increase economic and social resilience, and adaptive capabilities to potentially large long-term changes in environmental conditions.

The Way Forward

We use a four-order scheme to define disaster risk outcomes and associated societal processes. This frame-work can be implemented in the context of deliberative democracy and governance with participation of the community. The current dialog between science and society is not fully capable of supporting deliberative governance and a democratizing of knowledge. Most scientific knowledge is created independent of those who could put it to use, and a transition to co-design and co-development of knowledge involving a broad stakeholder base is necessary to address the disaster risk associated with extreme events. This transition may have the consequence of more responsibility and even liability for science.

Extreme Geohazards

Reducing the Disaster Risk and Increasing Resilience

Extreme geohazards have the potential to escalate the global sustainability crisis and put us close to the boundaries of the safe operating space for humanity defined by Rockström et al. (2009). Exposure of human assets to geohazards has increased dramatically in recent decades, and the sensitivity of the built environment and the embedded socio-economic fabric have changed. We are putting the urban environment, including megacities and core infrastructure, in harm's way. Triggering of anthropogenic hazards combined with global economic and social interdependence can amplify today's impact to hazards by several orders. Exposing today's civiliation to extreme events that occurred during the last few thousand years can help to understand the threat of these extreme events.

Are We Prepared for the next big event?

With support from the European Science Foundation (ESF), the Geohazards Community of Practice (GHCP) of the Group on Earth Observations (GEO) is preparing a White Paper on the risk associated with low-probability, high-impact geohazards. These extreme events are in general not sufficiently accounted for in risk management, although the potential impacts of these events are comparable to those of a large asteroid, a global pandemic, or an extreme drought. The White Paper aims to increase the awareness of the risk associated with extreme geohazards as a basis for a comprehensive risk management.

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ESF: http://www.esf.org

GHCP Geohazards Community of Practice

GEO

European Science Foundation
Setting Science Agendas for Europe

Deaths	Volcano	Year	Cause
92,000	Tambora, Indonesia 2)	1815	Starvation
36,417	Krakatau, Indonesia 1) 2)	1883	Tsunami
29,025	Mt. Pelee, Martinique	1902	Ash flows
25,000	Ruiz, Colombia	1985	Mudflows
14,300	Unzen, Japan	1792	Tsunami
9,350	Laki, Iceland 2)	1783	Starvation
5,110	Kelut, Indonesia	1919	Mudflows
4,011	Galunggung, Indonesia	1882	Mudflows
3,500	Vesuvius, Italy	1631	Mud&lava flows
3,360	Vesuvius, Italy	79	Ash flows

Table 1: Historic volcano eruption had large environmental impacts and most of them would today have far-reaching impacts disrupting crucial infrastructure at a continental to global scale.

1) Krakatau was similar to 1600 BC Santorini eruption, although about 4 times smaller.
2) These eruptions are presented in more detail as examples.

Volcanoes

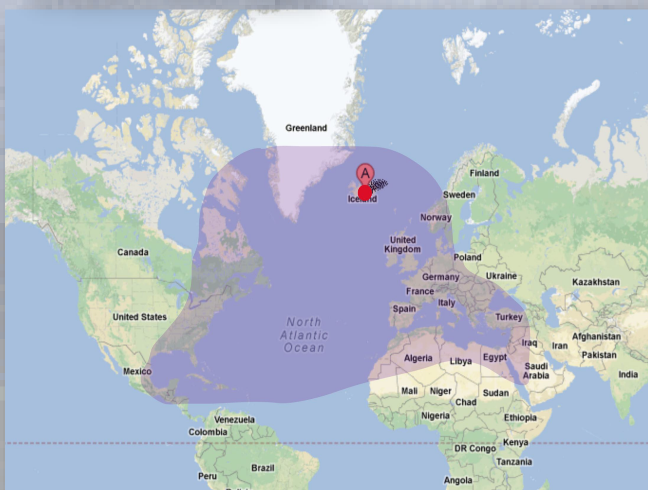

Figure 1: Extent of Areas Impacted by Volcano Ash During the Laki Iceland Eruption in 1783

Estimated deaths: 9,350. Little direct impact but the eight-month emission of sulfuric aerosols resulted in one of the most important climatic and socially repercussive events of the last millennium. The consequences for Iceland—known as the Mist Hardships—were catastrophic. An estimated 20–25% of the population died in the famine and fluorine poisoning after the fissure eruptions ceased. Around 80% of sheep, 50% of cattle and 50% of horses died because of dental and skeletal fluorosis from the 8 million tons of hydrogen fluoride that were released. There is evidence that the Laki eruption weakened African and Indian monsoon circulations, leading to between 1 and 3 millimetres less daily precipitation than normal over the Sahel of Africa. The resulting famine that afflicted Egypt in 1784 cost it roughly one-sixth of its population. The eruption was also found to have affected the southern Arabian Peninsula and India. In Great Britain, the summer of 1783 was known as the "sand-summer" because of the ash fallout. Impacts were reported throughout Europe, North America, and Gulf of Mexico. The eruptions contributing to several years of extreme weather in Europe.

Figure 2: Extent of Areas Impacted by Volcano Ash During the Mount Tambora Eruption in 1815

Estimated deaths: 71,000. Caused global climate anomalies that included the phenomena known as "volcanic winter", and in 1816 became known as the "Year Without a Summer". Impacted North America and Europe. Crops failed and livestock died in much of the Northern Hemisphere, resulting in the worst famine of the 19th century. Also created a 'Stratospheric Sulfate Aerosol Veil' which resulted in a persistent dry fog in Northern United States. Average global temperatures decreased about 0.4–0.7 K, enough to cause significant agricultural problems around the globe. Climate impacts are illustrated by frost and snow in June and subsequent months along the East coast of the USA. As well as a cooler summer, parts of Europe experienced a stormier winter. This pattern of climate anomaly has been blamed for the severity of typhus epidemic in southeast Europe and the eastern Mediterranean between 1816 and 1819 as well as a worldwide spread of a new strain of cholera originating in Bengal in 1816.

Estimated deaths: 36,417. The eruption began May 1883 culminating on August 26, 1883 at 13:00 and then August 27, 1883. Further seismic activity was reported until February 1884. Prior to the first eruption earthquakes were felt as far as Australia. The August 27 eruption was the most intense and could be heard 3,110 away in

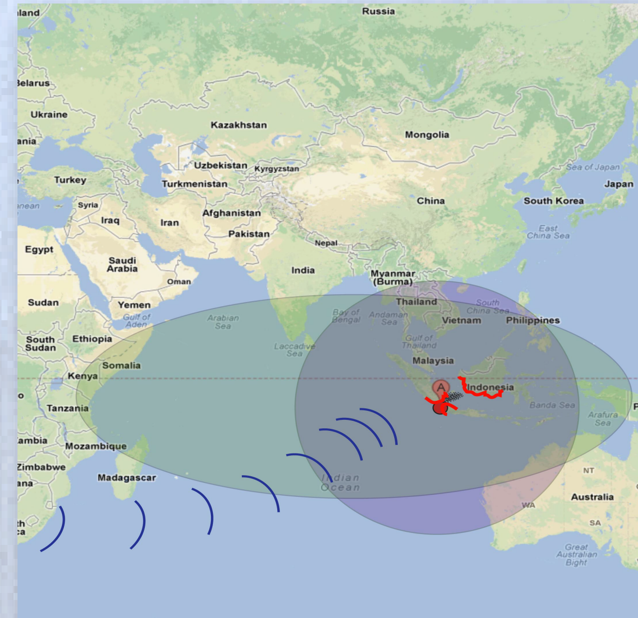

Figure 3: Extent of Direct Impact of the Krakatau, Indonesia Eruption 1883

Perth, Western Australia and the Indian Ocean island of Rodrigues near Mauritius 4,800 km away. Ash fall was seen in Ketimbang in Sebesi Island. Energy released estimated at 200 megatons of TNT. Ash was propelled to an estimated height of 80 km. Each of the August 27 explosions were followed by Tsunami, one estimated at over 30 m (100ft) in height. A large area of the Sunda Strait and a number of places on the Sumatran coast were affected by pyroclastic flows, which caused the tsunamis. Pressure waves radiated across the globe for more than five days.

Increasing Disaster Risk

Paradoxically, innovation during recent decades, in particular, urban innovation, has increased the disaster risk and coupled this risk to the sustainability crisis. Only more innovation can reduce disaster risk and lead us out of the sustainability crisis. Extreme geohazards (volcanic eruptions, earthquakes, tsunamis) that occurred regularly throughout the last few millennia mostly did not cause major disasters because population density was low and the built environment was not sprawling into hazardous areas to the same extent as today. Similar extreme events today would cause unparalleled damage on a global scale and could worsen the sustainability crisis. Simulation of these extreme hazards under present conditions can help to assess the disaster risk. The Geohazards Community of Practice of the Group on Earth Observations (GEO) with support from the European Science Foundation (ESF) is preparing a white paper assessing the contemporary disaster risks associated with extreme geohazards and developing a vision for science and society to engage in deliberations addressing this risk
(see http://www.geohazcop.org/projects/extgeowp).