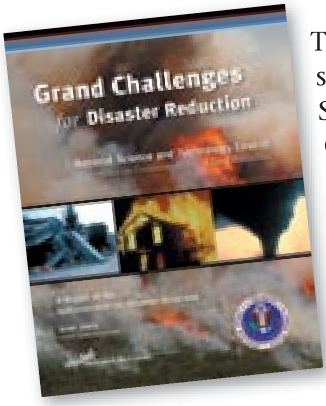

The *Grand Challenges for Disaster Reduction* outlines a ten-year strategy crafted by the National Science and Technology Council's Subcommittee on Disaster Reduction (SDR). It sets forth six Grand Challenges that, when addressed, will enhance community resilience to disasters and thus create a more disaster-resilient Nation. These Grand Challenges require sustained Federal investment as well as collaborations with state and local governments, professional societies and trade associations, the private sector, academia, and the international community to successfully transfer disaster reduction science and technology into common use.

To meet these Challenges, the SDR has identified priority science and technology interagency implementation actions by hazard that build upon ongoing efforts. Addressing these implementation actions will improve America's capacity to prevent and recover from disasters, thus fulfilling our Nation's commitment to reducing the impacts of all hazards and enhancing the safety and economic well-being of every individual and community. This is the volcano-specific implementation plan. See also **sdr.gov** for other hazard-specific implementation plans.

What is at Stake?

DEFINITION AND BACKGROUND. A volcano is a vent at the Earth's surface through which magma (molten rock) and/or associated gases erupt; it also refers to the cone-shaped hills and mountains built by erupted magma. Within the United States, 169 volcanoes are in current or recent eruptive state or are capable of reawakening in the future. However, only three of the most threatening volcanic centers in the U.S.— Kilauea, Mount St. Helens, and Long Valley Caldera—are monitored at levels commensurate with the threats they pose.[1]

IMPACTS. Following the 1980 eruption of Mount St. Helens, 57 people died, more than 500 sq km (311 miles) of forests, streams, and lakes were devastated,[2] and the surrounding communities suffered a $1 billion loss in 1980 dollars to the economy, forestry, agriculture, local businesses, and structures.[3,4] If such an eruption had occurred at Mount St. Helens in 2005, economic losses would have exceeded $3 billion.

An eruption of similar scale at Mount Shasta or Mount Rainier would result in greater loss. Fiery avalanches of volcanic rock, ash, and gas, termed pyroclastic flows, can reach more than 6,000 people[5] in the communities of Mount Shasta City and Weed on the flanks of Mount Shasta volcano in less than 10 minutes, and more than 100,000 people are at risk from debris flows, termed lahars, originating from Mount Rainier.[6]

In addition to hazards on the ground, clouds of volcanic ash emitted from erupting volcanoes pose a significant threat to aircraft en route. Since 1973, there have been more than 100 reports of jet-aircraft encounters with volcanic ash, several of them involving in-flight engine failure.[7] An estimated $100 million of damage was suffered by the aviation industry in Alaska as a result of the 1989–90 eruptions of Mount Redoubt alone.[8] Because volcanic ash clouds can be blown thousands of miles downwind, no U.S. volcano is too remote to represent a serious threat to air traffic.

VOLCANO

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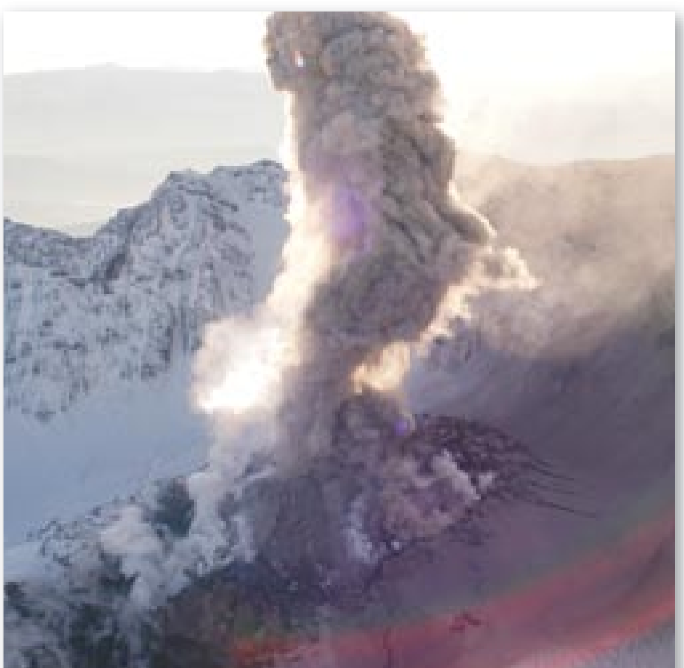
Nor is any community on the ground truly safe from the effects of the largest eruptions. Enormous volumes of ash and the gas SO_2, injected into the atmosphere by large eruptions, can cause global cooling, shortening growing seasons and reducing crop yields. For example, the eruption of Pinatubo in 1992 placed about 18.1 million metric tons (20 million tons) of SO_2 in the atmosphere, lowering the average temperature at Earth's surface by as much as 1.3°C (2.3°F) over 3 years,[9] and the eruption of Tambora volcano in Indonesia caused a "year without a summer" in North America in 1816, with snow storms and killing frosts in June, July, and August that were disastrous for New England agriculture.[10] Climatic effects of larger eruptions such as occurred at Yellowstone approximately 640,000 years ago would be prolonged and could threaten the very fabric of society.

Grand Challenges for Disaster Reduction: Priority Interagency Volcano Implementation Actions

GRAND CHALLENGE #1: Provide hazard and disaster information where and when it is needed.

- ■ Deploy a National Volcano Early Warning System, working with the Consortium of U.S. Volcano Observatories, Federal, state, and local emergency managers, and land-management agencies;
- ■ Establish a national 24x7 Volcano Watch Office with full alerting capabilities and authoritative information about unrest and eruptive activity;



- ■ Expand monitoring tool box to include emerging technologies such as Interferometric Synthetic Aperture Radar, and self-organizing, event-driven, smart monitoring networks;
- ■ Invest in information technology improvements, such as increased bandwidth, common software for data analysis, and neutral communication protocols to improve communication and data exchange between volcano observatories, Federal agencies, and responders;
- ■ Launch a United States civilian Synthetic Aperture Radar satellite;
- ➤ Expand efforts to improve monitoring capability at under-monitored volcanoes;
- ➤ Provide accurate forecasts of future ash cloud locations to aircraft controllers;
- ➤ Provide accurate forecasts of ash fall and air quality to emergency managers and health officials in affected communities;
- ◆ Increase satellite remote sensing capability for thermal imaging, detection of ash clouds by split-window technique, and detection of volcanic gas;
- ◆ Establish a readily accessible data archive of United States volcano monitoring data;
- ◆ Develop a worldwide database on volcanic activity by working with national and international partners (e.g., United States Group on Earth Observations, the Integrated Global Observing Strategy, and the Global Earth Observation System of Systems).

GRAND CHALLENGE #2: Understand the natural processes that produce hazards.

- ■ Improve eruption forecasts for high-threat volcanoes and improve understanding of magmatic processes beneath volcanoes based on long-term patterns of eruptive behavior as well as monitoring observations;
- ➤ Test utility of unmanned aerial vehicle platform-based analysis of volcanic gases (CO_2, SO_2, and others), and thermal, visual, and radar imaging;
- ➤ Improve source and transport terms for ash cloud models to better understand the movement, separation, and gas necessary to form the clouds;
- ◆ Determine the natural controls on eruptive style and create three-dimensional databases, or "virtual volcanoes," for each high-threat volcano that can be used to facilitate interpretation of monitoring results;

Key: ■ Short Term Action (1-2 years) ➤ Medium Term Action (2-5 years) ◆ Long Term Effort (5+ years)

- Develop global climate models for very large eruptions to predict their effects on the world's agriculture, natural resources, and economies.

GRAND CHALLENGE #3: Develop hazard mitigation strategies and technologies.

- Complete regional, national, and international volcanic ash response plans to ensure aviation safety, and partner with volcano observatories and civil aviation authorities worldwide under the auspices of the Federal Coordinator for Meteorology and the International Civil Aviation Organization to better share information relevant to mitigation of the volcanic-ash threat to aviation;
- Develop eruption response plans for all high-threat United States volcanoes to optimize mitigation by efficient avoidance and evacuation;
- Design and construct engineering solutions to slow, trap, or divert debris and lava flows, where practicable.

GRAND CHALLENGE #4: Reduce the vulnerability of infrastructure.

- Complete hazard assessments for all dangerous U.S. volcanoes to ensure communities, land managers, and developers have complete, accurate, and up-to-date information on volcanic hazards and volcanic activity in their area necessary to make eruption response plans and wise zoning and development decisions;
- Translate results from volcano hazard assessments into risk assessments based on up-to-date assessment of population, property, and infrastructure at risk;
- Evaluate the potential long-term impact of increased sediment loads near all high-threat volcanoes following eruptions on streams, rivers, wetlands, lakes, and dams;
- Develop plans for minimizing disruption to power grids, communication pathways, and transportation on the ground and in the air.

GRAND CHALLENGE #5: Assess disaster resilience.

- Develop comprehensive geographical informational systems coverage for all high-threat volcanoes and potentially affected areas to provide a detailed overall assessment of societal, economic, and environment vulnerability, and track improvements in disaster resilience in terms of reduced exposure of population and infrastructure to volcanic hazards;
- Evaluate potential direct impact of ash fall and volcanic blasts on agricultural lands and wildlands and the indirect impact caused by eruption-induced global climate change;
- Track improved avoidance of volcanic ash by aircraft in terms of reduced time that aircraft operate under uncertain eruption conditions.

GRAND CHALLENGE #6: Promote risk-wise behavior.

- Educate individuals living or working in potentially affected areas on volcanic hazards, and coordinate efficient use of monitoring systems, data, and communication, including standardized messaging systems, and land-use planning and decision-making across agencies and institutions;
- Establish regional, national, and international volcanic ash response plans for the aviation industry;
- Conduct disaster response drills to improve coordination between field responders, volcanologists, and emergency response centers.

Key: ■ Short Term Action (1-2 years) ➤ Medium Term Action (2-5 years) ◆ Long Term Effort (5+ years)

Expected Benefits: Creating a More Disaster-Resilient America

Fulfilling this volcano-specific implementation plan will create a more disaster-resilient America. Specifically:

Relevant hazards are recognized and understood. Improved understanding of volcanic behavior will allow decision makers to advance beyond early detection of a possible eruption to accurate forecast of its precise timing, violence, and duration. Comprehensive volcano monitoring using *in situ* monitoring networks and remote-sensing technologies will detect the tell-tale signs of unrest at reawakening volcanoes so that no U.S. volcano will erupt without individual awareness. Data produced by these monitoring activities will contribute to a steadily improving database on volcanic behavior that, coupled with process-oriented research, geologic studies to determine the "personality" of the Nation's most threatening volcanoes, and results from new technologies such as InSAR, will steadily improve understanding of processes that occur deep beneath volcanoes.

Communities at risk know when a hazard event is imminent. Comprehensive monitoring of all the Nation's volcanoes, coupled with improved understanding of volcanic processes, will increase warning times, which are currently in the range of hours or days, to weeks or longer, providing communities at risk time to prepare and evacuate, and ensuring that scientific, emergency management, and commercial response will not lag behind the evolving behavior of a volcano as it advances toward eruption. Volcanic unrest does not always culminate in eruption, and long-term volcano monitoring will provide sound, ongoing, scientific information to communities and emergency managers throughout unrest episodes so that problems related to over-reacting or under-reacting will be minimized.

Individuals at risk are safe from hazards. By receiving more accurate interpretations of unrest and forecasts of eruptive behavior, emergency managers and other decision makers will be able to respond appropriately and cost-effectively to volcanic hazards while assuring that no lives are lost and damage to property and disruption of transportation and communication networks are minimized. Timely and accurate warnings to en route aircraft will prevent dangerous encounters with volcanic ash while minimizing costly unnecessary redirection. Creation of ground evacuation and aviation response plans for the Nation's most dangerous volcanoes and implementation of a regular review schedule will ensure rapid and consistent transmission of warnings, enable cost-effective response, and minimize confusion, loss of life, and damage to property.

Disaster-resilient communities experience minimum disruption to life and economy after a hazard event has passed. Complete and accurate assessment of the potential volcanic hazards at each of the Nation's most threatening volcanoes will create valuable "behavioral histories" for each high-threat volcano and identify areas of greatest risk. This will provide a foundation for wise zoning and investment so that lives, property, and critical infrastructure and facilities such as fire stations and hospitals are not constructed in areas of high risk. As volcanoes advance toward eruption, communities will respond appropriately as a result of improved communication between scientists and decision makers through development of community response plans and improved public education on volcanic hazards. Improved understanding of volcanic processes will result in better forecasts of eruption violence and duration, minimizing the societal disruption of unnecessary evacuation.

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