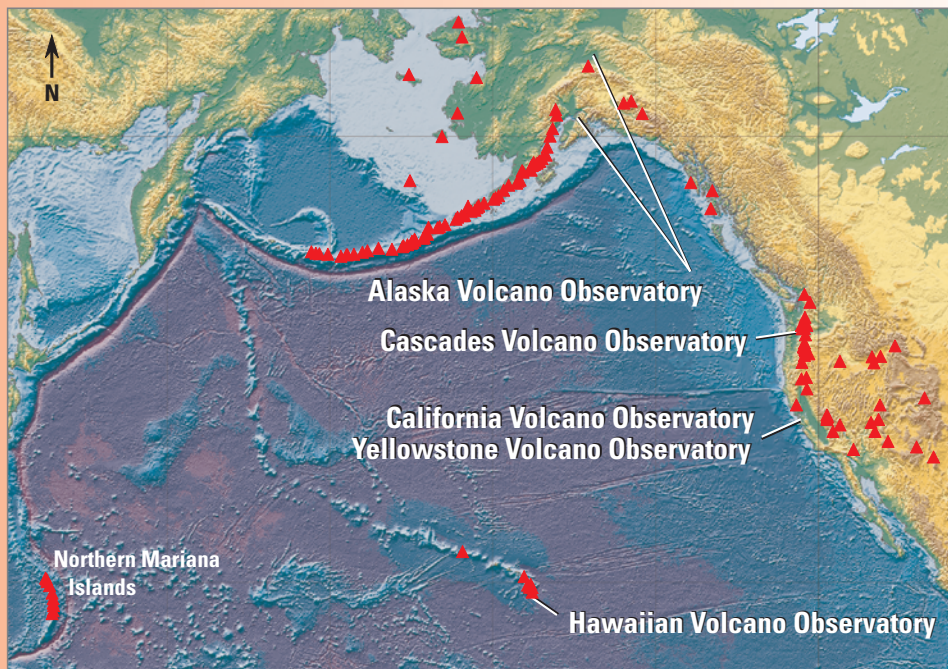


U.S. Geological Survey's Alert-Notification System for Volcanic Activity

The United States and its territories have about 170 volcanoes that have been active during the past 10,000 years, and most could erupt again in the future. In the past 500 years, 80 U.S. volcanoes have erupted one or more times. About 50 of these recently active volcanoes are monitored, although not all to the same degree. Through its five volcano observatories, the U.S. Geological Survey (USGS) issues information and warnings to the public about volcanic activity. For clarity of warnings during volcanic crises, the USGS has now standardized the alert-notification system used at its observatories.



The U.S. Geological Survey (USGS) is responsible for monitoring our Nation's 170 active volcanoes (red triangles) for signs of unrest and for issuing timely warnings of hazardous activity to government officials and the public. This responsibility is carried out by scientists at the five volcano observatories operated by the USGS Volcano Hazards Program and also by State and university cooperators.

The Need for a National Volcano Alert System

Under the Stafford Act (Public Law 93-288), the U.S. Geological Survey (USGS) has the Federal responsibility to issue timely and effective warnings of potential volcanic disasters. The USGS, through its five volcano observatories, determines the alert levels for a given volcano and notifies the appropriate Federal and State (and in some cases local) emergency management agencies of notable unrest and eruptive activity. Those agencies then start a process of disseminating information outward to other government and public organizations. Information is communicated to the public primarily through local and national news outlets and the Internet.

The USGS has now standardized the alert-notification system used at its volcano observatories. The goals of this alert-notification system are to (1) communicate a volcano's status clearly to nonvolcanologists, (2) help emergency-response organizations determine proper mitigation measures, and (3) prompt

people and businesses at risk to seek additional information and take appropriate actions. A key benefit of a standardized, nationwide alert system (**see inside pages for the notification scheme and definitions**) is that it minimizes confusion for those needing information about current threats from volcanic activity.

What Does the Alert-Notification System Need to Do?

To be effective the USGS alert-notification system needs to (1) accommodate the various sizes, styles, and durations of volcanic activity; (2) work equally well during escalating and deescalating activity; (3) be equally useful to both those on the ground and those in aviation; and (4) retain and improve effective existing alert-notification protocols.

Volcanic eruptions vary widely in size from insignificant to catastrophic. Most historical eruptions in the United States have been very small to moderate in size, but larger events are certain to occur in the future. Eruptions can range from passive lava

extrusions to highly explosive events that blast volcanic ash (tiny rock fragments) and gas more than 100,000 feet into the air. Eruptions may last for a day or continue for years or, in rare cases, many decades. Some volcanoes progress to eruption very quickly (days to weeks) and others take months to a year or more. Knowing when a volcanic eruption is subsiding is as important to those being affected as knowing when volcanic activity is escalating. A volcano alert-notification system must therefore take into account the up-and-down nature of volcanic activity.

Volcanic eruptions threaten both communities on the ground and people in aircraft, but in different ways. Eruptions pose a hazard to flying aircraft, especially jet aircraft, when volcanic ash is dispersed in the atmosphere. Numerous instances of aircraft flying into volcanic-ash clouds—resulting in loss of power to one or all engines and damaged electrical systems and windshields—have demonstrated both the life-threatening potential of this hazard and the economic costs [**continued on back page**].

The USGS Alert-Notification System for Volcanic Activity

Volcano Alert Levels Used by USGS Volcano Observatories

Alert Levels are intended to inform people on the ground about a volcano's status and are issued in conjunction with the Aviation Color Code. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption and about potential or current hazards and likely outcomes.

Term	Description
NORMAL	Volcano is in typical background, noneruptive state or, after a change from a higher level, volcanic activity has ceased and volcano has returned to noneruptive background state.
ADVISORY	Volcano is exhibiting signs of elevated unrest above known background level or, after a change from a higher level, volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
WATCH	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, OR eruption is underway but poses limited hazards.
WARNING	Hazardous eruption is imminent, underway, or suspected.

Newly standardized Alert Levels issued by USGS volcano observatories are based on a volcano's level of activity. These levels are intended to inform people on the ground and are issued in conjunction with the Aviation Color Code. The highest two alert levels (Watch and Warning) are National Weather Service terms for notification of hazardous meteorological events, terms already familiar to emergency managers that are becoming increasingly more familiar to the public. Alert levels are as follows:

NORMAL—The typical background state of a volcano when not erupting. It includes periods of increased steaming, seismic events, deformation, thermal anomalies, or detectable levels of volcanic degassing, as long as that activity is within the background range seen during its monitoring history or at similar types of volcanoes. It is not an “alert” level per se, inasmuch as no concern of potentially hazardous activity is implied. In some cases, unrest that is initially seen as “anomalous,” such as increased

steaming or elevated seismic activity, may after some time become considered normal background activity. At volcanoes that appear quiet but are not monitored with ground-based instruments, the absence of unrest cannot be confirmed; consequently, Normal is not assigned to such volcanoes.

ADVISORY—Declared when one or more volcano monitoring parameters are outside the background range of activity. Progression towards an eruption is by no means certain, but the volcano is closely watched to see how unrest develops. After being downgraded from a higher level, Advisory means that volcanic unrest has decreased significantly but that the level of unrest has not yet reached background.

WATCH—Declared for two different situations: (1) heightened or escalating unrest indicating a higher potential that an eruption is likely but still not certain or (2) an eruption that poses only limited hazards to people on the ground. In situation 2, it is implied that erupting volcanoes are inherently unstable and that condi-

tions could change quickly. After downgrading from Warning to Watch, this level indicates that the potential for renewal of hazardous eruptive activity is high (situation 1) or that the volcano has settled into an eruptive style that poses only limited hazards (situation 2).

WARNING—Declared when a highly hazardous eruption is underway, suspected, or believed to be imminent. Such events include large explosive eruptions that could destroy nearby communities and cause volcanic ash to fall on others downwind, eruptions of lava that are flowing towards nearby homes, and eruptions that could spawn powerful volcanic mudflows (lahars) that might inundate downstream communities. During an eruption, information accompanying the alert levels and frequent updates will indicate in as much detail as possible the time of onset, intensity, ash-plume height, and types of hazardous phenomena. When an eruption ends or settles into milder, less hazardous activity the level is downgraded.

Hazards to People on the Ground



Pyroclastic flows (high-speed avalanches of hot volcanic ash and gases)—a potential hazard at many active U.S. volcanoes—race down the flanks of Soufriere Hills Volcano, Montserrat, British West Indies, during an eruption in 1997.

Bicyclist in Anchorage, Alaska, wearing dust filter after a minor ashfall from the 1992 eruption of Mount Spurr Volcano.



Hot, glowing lava flow from Kilauea Volcano burying a road on the Island of Hawai'i in 1983.



House damaged by debris from a lahar (volcanic mudflow) during the May 18, 1980, eruption of Mount St. Helens, Washington.

Aviation Color Code Used by USGS Volcano Observatories

Color codes, which are in accordance with recommended International Civil Aviation Organization (ICAO) procedures, are intended to inform the aviation sector about a volcano's status and are issued in conjunction with an Alert Level. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption, especially in regard to ash-plume information and likely outcomes.

Color	Description
GREEN	Volcano is in typical background, noneruptive state or, after a change from a higher level, volcanic activity has ceased and volcano has returned to noneruptive background state.
YELLOW	Volcano is exhibiting signs of elevated unrest above known background level or, after a change from a higher level, volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
ORANGE	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, OR eruption is underway with no or minor volcanic-ash emissions [ash-plume height specified, if possible].
RED	Eruption is imminent with significant emission of volcanic ash into the atmosphere likely OR eruption is underway or suspected with significant emission of volcanic ash into the atmosphere [ash-plume height specified, if possible].

Aviation Color Code notifications are issued in conjunction with the Volcano Alert Levels used to inform people on the ground. Color codes are especially suitable for the aviation sector because pilots, dispatchers, and air-traffic controllers planning or executing flights over broad regions of the globe need to ascertain quickly the status of numerous volcanoes and determine if continued attention, rerouting, or other measures are warranted.

The Aviation Color Code is in accordance with recommended International Civil Aviation Organization (ICAO) procedures. The color code places special emphasis on volcanic ash in the atmosphere, because ash can cause jet engines to fail in flight. Also, wind can carry ash clouds thousands of miles, creating a hazard to jet aircraft far distant from the erupting volcano. Aviation Color Code definitions are similar to those for Volcano Alert Levels and, like them, are based on a volcano's activity:

GREEN—Applies to the typical background state of a volcano when not erupting. At volcanoes that appear quiet but are not monitored with ground-based instruments, the absence of unrest cannot be confirmed; consequently, Green is not assigned to such volcanoes. It is not an “alert” level per se, inasmuch as no concern of potentially hazardous activity is implied.

YELLOW—Declared when one or more monitoring parameters at a volcano are outside the background range of activity. Progression towards an eruption is by no means certain, but the volcano is closely watched to see how unrest develops. After being downgraded from a higher level, Yellow means that volcanic unrest has decreased significantly but that the level of unrest has not yet reached background.

ORANGE—Used for two different situations: (1) heightened or escalating unrest indicating a higher potential that an eruption is likely

but still not certain (the timeframe to eruption or cessation of unrest is variable) or (2) an eruption that poses only a minor hazard to aviation because of limited amounts of ash in the atmosphere or low ash-plume heights. After downgrading from Red to Orange, this level signifies that the potential renewal of hazardous eruptive activity is high (situation 1) or that the volcano has settled into an eruptive style that poses only limited hazards (situation 2).

RED—Declared when an explosive eruption is underway, suspected, or imminent that is releasing or likely to release a significant amount of ash into the atmosphere. During such events, accompanying information will indicate in as much detail as possible the time of onset, intensity, and ash-plume height. There will be frequent updates with detailed accompanying text to report on the progression of the eruption. When the eruption ends, or settles into milder activity with no or minor ash emissions, the level will be downgraded.

Volcanic Ash—A Hazard to Aviation



Airliner taking off from Portland International Airport with Mount Hood Volcano, 35 miles to the east, looming above the landscape. This active volcano last erupted about 200 years ago. Volcanic ash clouds from an explosive eruption of Mount Hood could create a major hazard for jet aircraft. (Photo courtesy of Port of Portland.)

Large plumes or clouds of volcanic ash from an erupting volcano can make a local problem a national or an international concern. This is especially true for aviation, because ingesting ash can cause jet engines to fail in flight. This image taken from the International Space Station in 2002 shows an eruption plume extending hundreds of miles downwind from Mount Etna, Italy (photo courtesy of NASA). Insets show a closeup of volcanic ash (top) and a view of an ash particle magnified about 200 times (bottom).

The best strategy for the aviation industry is to avoid ash encounters, which requires that pilots, dispatchers, and air-traffic controllers quickly learn of explosive volcanic eruptions and the location (altitude and areal coverage) of ash clouds.

Communities on the ground, however, may face multiple volcanic hazards—including mudflows, lava-flow inundation, and pyroclastic flows (high-speed avalanches of hot volcanic ash and gases), as well as falling ash—and must evacuate or cope with the situation in place. Although ashfall is rarely lethal by itself to people, even small amounts of ash on the ground can greatly disrupt daily life and can be extremely difficult to clean up.

Alert Levels

Because the new USGS alert-notification system for volcanic activity is designed to be useful both to people on the ground and to those in aviation, the notification system has two parts—(1) a 4-tiered Volcano Alert Level, which uses the terms **Normal**, **Advisory**, **Watch**, and **Warning** (from background to highest threat; all but **Normal** are terms used by the National Weather Service for meteorological events) and (2) a 4-tiered Aviation Color Code of **Green**, **Yellow**, **Orange**, and **Red** (see interior pages). USGS communications during unrest and

eruptions will include both the Volcano Alert Level and the Aviation Color Code.

During unrest (either escalating or deescalating) and during most eruptions, the “alert-level term” and “code color” will change together (for example, **Normal** and **Green**; **Advisory** and **Yellow**; **Watch** and **Orange**; **Warning** and **Red**). However, during some volcanic eruptions, hazards to people on the ground and to aviation may differ substantially. In these cases, the Volcano Alert Level and Aviation Color Code will move independently. For example, an eruption of a lava flow that threatens a community but produces no significant ash might warrant a Volcano Alert Level of **Warning** but an Aviation Color Code of **Orange**. On the other hand, an eruption that produces a huge cloud of volcanic ash that does not drift over inhabited areas might warrant a Volcano Alert Level of **Watch** and an Aviation Color Code of **Red**.

Volcano observatory scientists determine alert levels for a volcano by using monitoring data and their knowledge of the expected or ongoing hazardous activity. By themselves, alert-level terms and code colors do not convey enough information for those in affected communities and aviation to make decisions regarding specific courses of actions. Therefore, details about the volcanic activity accompany any notifications of changes in alert levels, and these details are updated frequently. The combination of alert-level changes and detailed accompanying information is designed to gain the attention of government officials and the public and to give them sufficient time and information to take appropriate actions in response to volcanic unrest.

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How do the Volcano Alert Level and Aviation Color Code Work With Each Other?

During volcanic unrest and most eruptions, the Volcano Alert Level and Aviation Color Code will change upwards or downwards together. However, during some eruptions, they may change independently because the hazards associated with the eruption may be different for people on the ground than for people in aircraft.

Example of levels changing together: During a relatively quiet, nonexplosive dome-building eruption that neither threatens populated areas nor is expected to produce a volcanic ash cloud. (Photograph of dome-building eruption at Mount St. Helens, 2006.)



Volcano Alert Level

WATCH

Eruption is underway but poses limited hazards.

Aviation Color Code

ORANGE

Eruption is underway with no or minor volcanic-ash emissions.

Example of levels changing independently: During a nonexplosive eruption, producing no significant amounts of volcanic ash, in which flowing lava has entered populated areas. (Photograph of lava flows from Kilauea Volcano, Hawaii, 1986.)



Volcano Alert Level

WARNING

Hazardous eruption is underway.

Aviation Color Code

ORANGE

Eruption is underway with no or minor volcanic-ash emissions.

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For Volcanic Activity Updates see
<http://volcanoes.usgs.gov/>

See also What are Volcano Hazards? (USGS Fact Sheet 002-97), Volcanic Ash—A “Hard Rain” of Abrasive Particles (USGS Fact Sheet 027-00), Volcanic Ash—*Danger to Aircraft in the North Pacific* (USGS Fact Sheet 030-97), *Volcanic Ash and Aviation Safety—Proceedings of the First International Symposium on Volcanic Ash and Aviation Safety* (USGS Bulletin 2047)

This Fact Sheet and any updates to it are available online at
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