FACT SHEET

GOES-R
Volcanic Ash Detection

Why are volcanic eruptions hazardous?

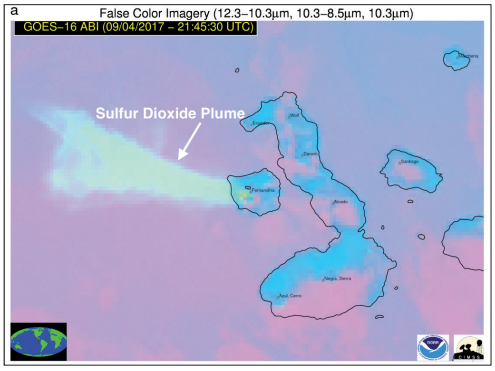
Volcanic ash is a significant health, aviation, infrastructure, and economic hazard. When ingested into aircraft engines, volcanic ash can lead to engine damage or failure. Volcanic ash is extremely abrasive and even small concentrations can severely damage the exterior of aircraft. In addition, ashfall poses substantial health and infrastructure threats to those on the ground. Breathing volcanic ash can result in serious illness or death and ashfall can also pollute water supplies and damage or destroy buildings. Volcanic eruptions also often produce a noxious gas, sulfur dioxide (SO_2). Inhaling SO_2 is associated with increased respiratory symptoms and disease.

An ash plume rises from the Kilauea volcano in Hawaii on May 15, 2018. Credit: U.S. Geological Survey

Why is it important to monitor volcanoes from space?

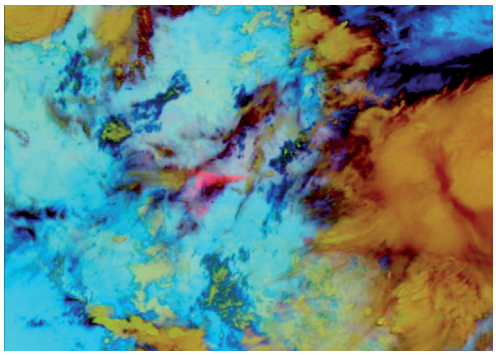
Volcanic emissions generate complex clouds that can affect local, regional, or, in the case of very large eruptions, global weather and climate. Given the remote location of most volcanoes and the rapid formation and expansion of volcanic clouds, geostationary satellites are the primary tool for identifying, tracking and characterizing volcanic clouds. GOES East and GOES West observe a significant fraction of the most volcanically active region on Earth, known as the "Pacific Ring of Fire," which includes the western portions of North and South America, East Asia, Indonesia, Micronesia, and New Zealand.

How do GOES-R Series satellites monitor the hazards from volcanic eruptions?



GOES-16 false color ash RGB image of the Fernandina volcano in the Galápagos Islands on September 4, 2017. This volcanic plume was rich in SO_2, depicted as a green plume in this imagery. Credit: NOAA/CIMSS

The GOES-R Series **Advanced Baseline Imager (ABI)** has several channels (or bands) that are sensitive to volcanic ash. ABI also has significantly improved resolution and faster coverage than previous GOES imagers, allowing for better identification of volcanic clouds. ABI is also sensitive to SO_2. **Sulfur dioxide detection** is a new capability offered by the ABI, due to new infrared channels that previous GOES imagers lacked. Even more so than volcanic ash, geostationary satellite-based volcanic SO_2 detection is revolutionized with the ABI.

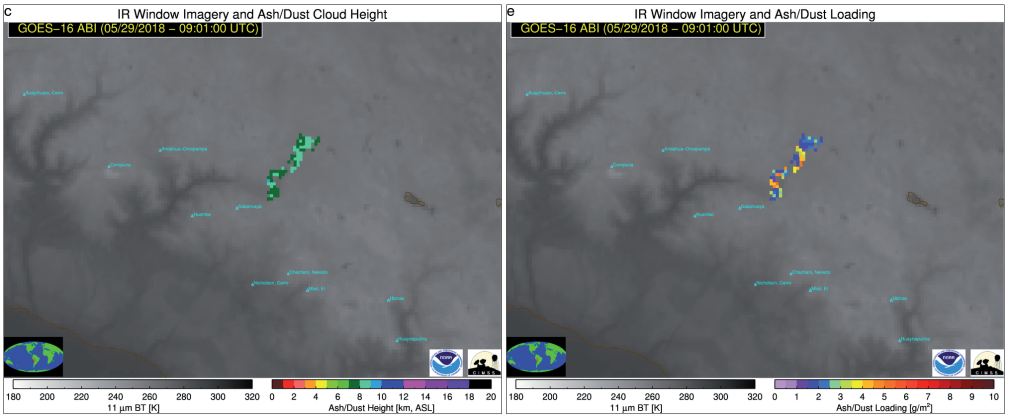


Volcanic ash from the September 27, 2017, eruption of the Popocatepetl volcano in Mexico was detected by GOES-16. The reddish pink colors indicate ash. The other colors denote the following: yellowish/brown colors are thick clouds, the dark blues are thin cirrus clouds, and the pale blue indicates the surface (land and water) of the Earth. Credit: NOAA/CIRA

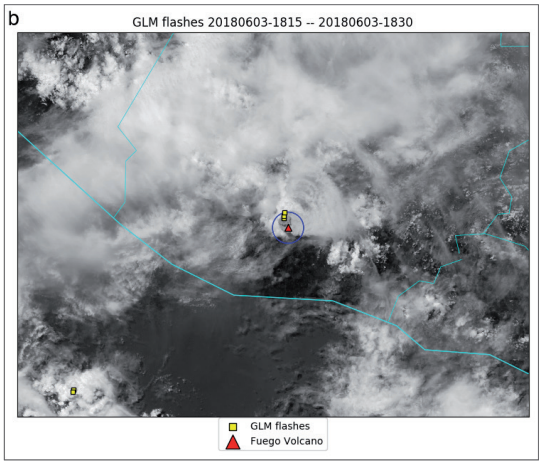
Visible and infrared ABI channels can be combined to create RGB (red-green-blue) imagery that allows for better discernment of features like ash and hot spots. In **volcanic ash RGB** imagery, ash is shown as reddish pink, thick clouds as yellowish brown, think cirrus clouds as dark blue, and Earth's surface (land and water) as pale blue. **Fire temperature RGB** imagery is used to detect hot spots from volcanic fire. Active hot spots show up as red, yellow and white as the fires grow increasingly hotter.

The advanced capabilities from GOES-R Series satellites also allow for new detection tools. The **VOLcanic Cloud Analysis Toolkit (VOLCAT)** is an artificial intelligence application developed by NOAA, in partnership with the

University of Wisconsin-Madison. VOLCAT generates alerts when volcanic unrest or an eruption is detected and also automatically tracks and characterizes volcanic clouds. VOLCAT combines multiple ABI infrared channels to determine the presence of ash, estimate the height of ash clouds, determine the extent of ash, and estimate the amount of ash present in each satellite pixel. VOLCAT allows for far more timely detection of volcanic eruptions and more accurate ash cloud characterization than was previously possible and supports real-time decision making.



GOES-16 VOLCAT ash height (left) and ash mass loading (right) from the Sabancaya Volcano eruption in Peru on May 29, 2018. Credit: NOAA/CIMSS



GOES-16 ABI visible imagery from June 3, 2018, of the Fuego Volcano eruption with GLM lightning data overlaid (yellow squares) in the area circled on the image. Credit: NOAA/CIMSS

Explosive volcanic eruptions often generate lightning. The GOES-R Series **Geostationary Lightning Mapper (GLM)** has potential to improve eruption detection and characterization. On June 3, 2018, a series of explosive events from the Fuego volcano in Guatemala generated lightning. GLM observed flashes for the first explosive event, and initial analysis suggests that attributes of the GLM-observed lightning from the volcanic event differed from lightning associated with nearby meteorological convection. Additional analysis is needed, but this unique application could prove beneficial. The combination of GLM and ABI data may produce new insights about volcanic eruptions and volcanic cloud behavior.

What are the benefits of the GOES-R Series observations of volcanic hazards?

As airborne volcanic ash has significant aviation, health, infrastructure, and economic effects, frequent observation of volcanic regions and prompt identification of ash clouds are necessary to minimize risk. ABI's advanced spectral, spatial and temporal resolution results in a complete set of sophisticated volcanic cloud detection and monitoring products and tools.

Forecasters use GOES-R volcanic ash applications to identify areas where volcanic ash is present and potentially hazardous, and ultimately issue more accurate aviation, air quality, ground safety, and public health warnings. The new ash detection and monitoring tools are useful for improving the modeling of volcanic ash clouds, allowing for more accurate ash cloud dispersion and ashfall forecasts. The more accurate mass loading detection may also aid in forecasting short-term climate changes due to volcanic eruptions.

As forecasters gain more experience with new GOES-R Series datasets, the value of the measurements will increase significantly. With continued development of GOES-R tools, volcanic hazard forecasting and monitoring will improve considerably, resulting in safer and more efficient air transportation and a better understanding of volcanic processes and the complex relationship between volcanic emissions and weather and climate.

Contributors: Michael J. Pavolonis (NOAA/NESDIS/STAR), Justin Sieglaff (CIMSS), John Cintineo (CIMSS)

Related links:

Volcanic Ash Advisory Centers: www.ssd.noaa.gov/VAAC/vaac.html

VOLCAT products: https://volcano.ssec.wisc.edu/