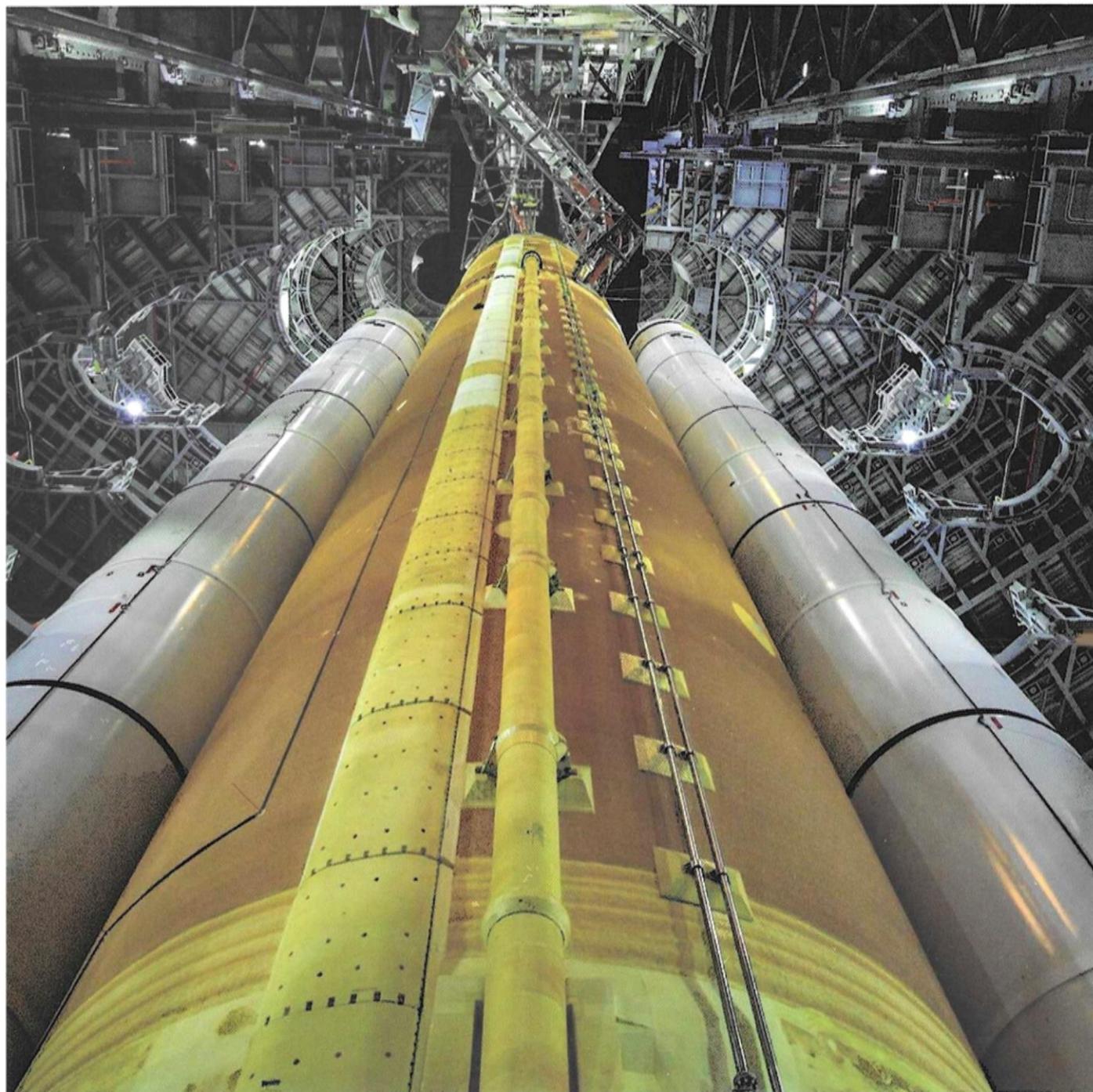




# THE SPACE REPORT

THE AUTHORITATIVE GUIDE  
TO GLOBAL SPACE ACTIVITY

2 0 2 2 Q1



2022 MAIDEN FLIGHTS | LATEST U.S. WORKFORCE DATA | NATION IN REVIEW: SOUTH KOREA



**Introduction** | *The recent eruption of an underwater volcano on Hunga Tonga-Hunga Ha'apai, an uninhabited island in the South Pacific archipelago of Tonga, was possibly the largest eruption ever witnessed during the satellite era.<sup>1</sup> Multiple Earth observing satellites from organizations all over the world captured the eruption in near real time and to a degree of detail not possible just a few years ago.<sup>2</sup> The unexpected data collected from the satellites is helping reshape our understanding on the local and global effects of submarine volcanos.<sup>3</sup> Space technology is helping restore communications, too.*

Tongan volcanic eruption on Jan. 15, 2022, captured by the GOES-West satellite.  
Credit: NASA Worldview, NOAA/NESDIS/STAR

## Satellite Data from Tonga Eruption Brings New Insight into Volcanoes

The Tongan Islands sit along the Tonga-Kermadec volcanic arc, which consists of a string of volcanoes directly above a geological collision zone,<sup>3</sup> and are home to approximately 105,000 people.<sup>4</sup> Hunga Tonga-Hunga Ha'apai is located about 62 miles northwest of Tonga's capital of Nuku'alofa on the main island of Tongatapu.<sup>5</sup> It once existed as the two small islands of Hunga Tonga and Hunga Ha'apai until eruptions in late 2014 and early 2015 connected them by forming a new land mass.<sup>6</sup>

The most recent volcanic activity began in late December 2021 and climaxed in an eruption on Jan. 15, 2022, that shot an ash cloud 12 miles into the air, which expanded to a radius of 162 miles.<sup>7</sup> The blast of the volcano was estimated at around 10 megatons of TNT by NASA's Goddard Space Flight Center, which is 500 times more powerful than the atomic bomb dropped on Hiroshima, Japan, during World War II.<sup>8</sup> The eruption triggered tsunami waves that traveled as far as the west coast of the United States and created pressure waves in the atmosphere that spread around the world. The blast was so powerful that it left all but two small pieces of the island of Hunga Tonga-Hunga Ha'apai below water.<sup>9</sup>

The damages inflicted on the region of Tonga were twofold. The United Nations estimated nearly an inch of ash from the blast cloud covered the main island of Tongatapu.<sup>10</sup> This thick layer of ash contaminated drinking water and caused approximately \$17 million in damage to crops.<sup>11</sup> The islands were also hit by tsunami waves that rose as high as 49 feet.<sup>12</sup> These massive waves caused at least three deaths in Tonga and swept away buildings, cars, and power lines.

The dangers experienced by the Tongan people were intensified by their lack of communication with the outside world.<sup>13</sup> The eruption severed the underwater optical fiber cable that provides internet and other communications to the islands. One of the first successful means of communication in the days following the eruption was the "Chatty Beetle."<sup>14</sup> This portable Iridium satellite terminal can send and receive text-based messages from isolated locations and allowed the staff at Tonga Meteorological Service to notify outside agencies that they were safe but communication networks were down. The



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Pacific International Training Desk (PITD) instructor David Hitzl with Sponberg “Chatty Beetle” at the University of Hawaii at Manoa. Image Credit: Pacific International Training Desk at the University of Hawaii

Chatty Beetle is a collaborative project between the National Oceanic and Atmospheric Administration’s (NOAA) National Weather Service, the University Corporation for Atmospheric Research (UCAR), and the University of Hawaii. The device runs on internal batteries, can withstand harsh conditions, and is capable of two-way messaging that allows status reports and potential hazard alerts to be transmitted.

SpaceX, Elon Musk’s space exploration company, is also assisting Tonga by restoring internet connectivity to the islands.<sup>15</sup> A team from Starlink, the constellation satellite division of SpaceX, will be in Fiji for six months to establish a gateway station to reconnect Tonga to the rest of the world.

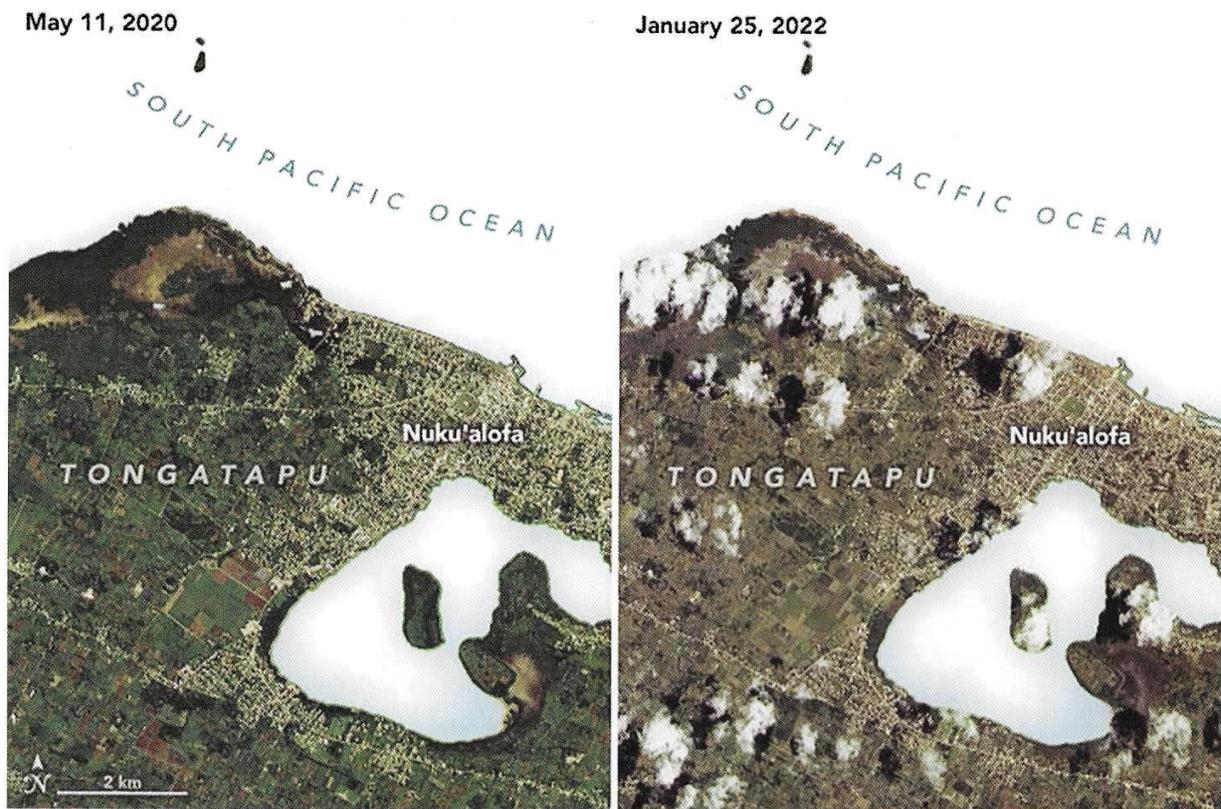
Without traditional methods of communication, satellites help determine where and when to send resources after a natural disaster.<sup>16</sup> Damage proxy maps are created using satellite radar images from before and after the disaster strikes. These maps offer wide views of the destruction and help first responders establish where to send aid first. The maps made after the Tongan eruption were produced with Synthetic Aperture Radar (SAR) images from the Advanced Land Observing Satellite-2 (ALOS-2) operated by the Japan Aerospace Exploration Agency (JAXA).



Geologists on site as the Tonga volcano erupted, sending plumes up to 20 kilometers above sea level. Credit: Tonga Geological Services

### Volcanic Eruption Research

The unprecedented effects of the eruption of Hunga Tonga-Hunga Ha’apai were felt around the world. The blast was captured by NOAA’s Geostationary Operational Environmental Satellite 17 (GOES-17 or GOES-West)<sup>17</sup> and the Japan Meteorological Agency’s Himawari-8 satellite.<sup>18</sup> With the volcano sitting at a maximum of 820 feet under the surface of the ocean, the water pressure wasn’t enough to stifle the blast and it rose at least 19 miles into the stratosphere. However, magma still mixed with large amounts of water, which added to the power of the eruption by creating steam.



The difference in Tongatapu between May 2020 and January 2022 as seen from space.  
Credit: NASA Earth Observatory, USGS/Landsat, JAXA/ALOS-2, Earth Observatory of Singapore Remote Sensing Lab

Due to the remote location of many volcanoes and their quick, violent nature, it is estimated that 90% of the world's volcanoes are not regularly monitored. Satellites are the primary tool used to monitor ash clouds from volcanic activity.<sup>20</sup> Satellites avoid the destruction by viewing the blasts from far above the Earth and can estimate the height and amount of ash produced, which is important for air travel safety. NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission indicated that the ash material from Hunga Tonga-Hunga Ha'apai expanded to a height of 25 miles after the initial blast.<sup>21</sup> According to Jason Tackett, a researcher at NASA's Langley Research Center, this is the highest ash altitude measured by CALIPSO since it was launched by NASA and France's National Centre for Space Studies (CNES) in 2006. Natural-color images from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Aqua satellite<sup>22</sup> and the Operational Land Imager (OLI) on the United States Geological Survey's (USGS) Landsat 8 satellite reveal how the ash impacted the Earth at the surface.<sup>23</sup> Images from the satellites show large amounts of ash and pumice blanketing the land and discoloring the water.

The blast also shook the atmosphere from the surface to the ionosphere and released a variety of waves that moved throughout the oceans and the atmosphere.<sup>24</sup> The volcano unleashed several types of waves, including infrared, infrasound, acoustic-gravity, and tsunamis through the Pacific.



Mathew Barlow, a professor of environmental, Earth, and atmospheric sciences at the University of Massachusetts Lowell, used electromagnetic wavelength data from the GOES-West satellite to study the atmosphere after the eruption.<sup>25</sup> He observed that the waves moved through the atmosphere and across the Earth in just a few hours and disturbed air temperature and water vapor as it traveled. Cathryn Mitchell, a physicist at the University of Bath in the United Kingdom, used ground and space-based sensors to find that waves reached into the ionosphere, which starts 50 miles above the surface of the Earth.<sup>26</sup>

Data from the Atmospheric Infrared Sounder (AIRS) aboard the Aqua satellite also revealed this eruption was unique with no comparable measurements taken by AIRS since it launched in 2002, according to Lars Hoffman of the Jülich Supercomputing Centre in Germany.<sup>27</sup> Measurements show fast-moving atmospheric gravity waves, which occur when energy and momentum are transmitted through the atmosphere by air molecules shifting vertically in the air column. They moved in dozens of concentric circles and extended to over 9,900 miles. Scott Osprey, a climate scientist at the University of Oxford in the United Kingdom, warned that these gravity waves could have a lasting impact on weather patterns. The waves are capable of changing wind directions in the tropics and altering the weather in other continents.

#### **More Research Needed to Determine Volcanic Impact**

Additional research is needed to establish the long-term effects of the eruption of Hunga Tonga-Hunga Haʻapai.<sup>28</sup> Moving forward, scientists will be looking for any damage to stratospheric ozone as well as any indication that the ash in the atmosphere altered the climate. Further study is also required to determine whether the atmospheric waves will change weather circulation patterns.

Satellite data can also be utilized to improve tsunami early warning systems.<sup>29</sup> Information from the Global Navigation Satellite Systems (GNSS) is already being used to detect ground movement that cause tsunamis, and additional data will likely be incorporated into warning systems in the future.

Although Earth observing satellites were able to collect large amounts of data, the unparalleled measurements taken from the eruption of Hunga-Tonga Hunga-Haʻapai are forcing the scientific community to alter previous assessments of the dangers underwater volcanoes pose.<sup>30</sup>



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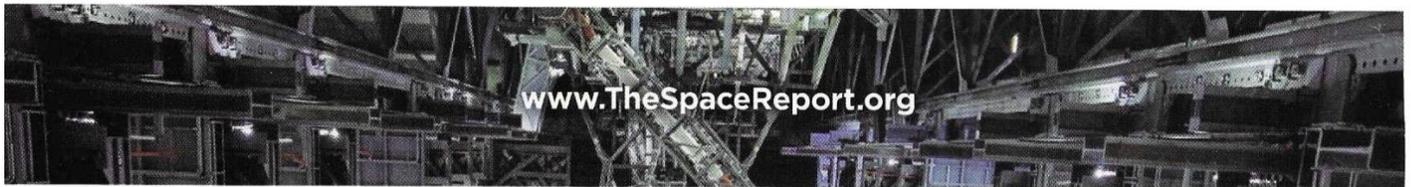
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