The Earth Whisperer
When the planet speaks, geophysicist Rhett Butler listens

On the morning of April 1, 1946, the tide mysteriously rose past the highest markers in Hilo Bay. Then the water disappeared, draining out of the bay entirely. Boats listed on the rocks and fish flopped on exposed seabed. Then it came: a crushing, thirty-two-foot wave that surged inland and destroyed almost a third of the city—one of the worst natural disasters in Hawaii’s recorded history. More than 2,400 miles away, a major earthquake in the Aleutian Islands had triggered the tsunami, one that struck without warning.

“This was the event that ultimately led to the creation of the Pacific Tsunami Warning System,” says Rhett Butler, former director of the Hawaii Institute for Geophysics and Planetology. Today there would be warning: Earth-monitoring sensors provide data on global seismic activity to help scientists predict and model tsunami events. Butler’s work directing this Global Seismographic Network (GSN), advocating for increased seafloor monitoring and coordinating with local...
emergencies response planners has made the Hawaiian Islands—and the rest of the world—safer. “There’s my little homemade seismometer,” Butler says, pointing to a precariously balanced stack of pebbles on a shelf in his office at the University of Hawai‘i’s School of Ocean and Earth Science and Technology (SOEST). He’s half-joking but sincere. “If the building ever vibrates, these will fall over.” He says the stones have toppled more than once, but never while Butler was there to see it. Despite decades studying earthquakes, he has yet to experience one himself.

Cheerful and unassuming in his trademark bright aloha shirt, Butler is both wry and passionate when discussing the movement of the earth. He describes the slowest of Earth’s natural vibrations, a sluggish oscillation that takes about an hour between peaks. “I believe Earth is the greatest tai chi master of all,” Butler quips. But when it comes to fault lines and fractures, few are more serious.

In a career spanning more than forty years, Butler has traveled the globe supervising seismographic efforts in some of the world’s most remote locations and deepest oceans. Coordinating GSN programs for agencies including the National Science Foundation, NASA and the Department of Defense, he’s worked in places as disparate as Washington, D.C., Hawai‘i, and Antarctica. Butler has partnered with UH since 1982 and has called Hawai‘i home for the past eighteen years. During that time Butler, alongside colleagues at UH and among the global earth science community, has made major advances in our understanding of the planet we all call home.

Butler’s interest in science started when he was a boy fascinated with the way things work. A family trip to Boston included lunch across the street from the Massachusetts Institute of Technology, and Butler decided on the spot that he would go there for college. After graduating high school in his hometown of Coshocton, Ohio, Butler made the cut and was off to MIT.

In case you were wondering: Yes, Butler is named after the character Rhett Butler from Gone with the Wind, but the real Rhett Butler never really gave a damn about it. “I grew up in a small town, and in elementary and high school no one had ever said anything about my name,” he says. “But on my first day at MIT, everyone commented on it—my name didn’t even show up on the rolls for my classes because the school thought it was a prank and deleted it!” Once the error was corrected, Butler went on to earn his degree in earth and planetary science. From there he shifted to doctoral studies in geophysics at Caltech, which is where he discovered that seismology matters. From its modest beginnings in 1986 through today, the GSN has grown to include more than 150 land-based seismic monitoring stations that record movements large and small. The sources
of seismic activity they detect is diverse: earthquakes, landslides, volcanic eruptions and more. Even meteorite impacts create planetary vibrations. Besides sensing seismic events that could trigger tsunamis, another practical application of the network has been monitoring international nuclear arms testing to help enforce treaties. The sensors act almost like microphones, able to pick up even the slightest vibration. Acoustic waves measured by microphones are scalar, or one-dimensional. But seismic waves are measured as vector motion in all the directions of three-dimensional space, and the seismic equipment has to be extremely sensitive to accurately track and record those movements. Now when a tree falls in the forest with nobody to hear it, there’s a decent chance that a GSN sensor will detect it.

Butler has been instrumental in getting those sensors into some of the most remote places on Earth. “I think probably the most interesting place I’ve been is the South Pole,” Butler says. As a program manager for the Incorporated Research Institutions for Seismology (IRIS) in the 1980s, he was responsible for the polar seismic station that had been in place since 1957. It was the oldest continuously operating data stream out of the South Pole.

Despite whimsically taking photos at the pole in one of his colorful aloha shirts, Butler holds a deep respect for the severity of the environment. “You go out there in the summer and the sun never sets. It goes around in a halo overhead. We got under some of the ice tunnels where it was minus eighty degrees, and that is cold!” Butler remembers being interviewed by a visiting team from the Discovery Channel. “The interview lasted until the camera froze, and that was it.” But when the site became busier as a science hub, with astronomers and physicists moving in to study neutrinos from deep space and conduct other experiments, the noise started to corrupt some seismic readings. “We could sense tractors driving around the pole. We’d pick that up, and every time a plane landed or a snowmobile drove past the sensors. We’d pick up absolutely everything.”

Butler’s solution was to move the seismic station eight kilometers away from the main research center. “We drilled boreholes nearly a thousand feet into the ice, put seismometers in, then buried an observatory building under the ice and hooked it all up with fiber-optic line back to the pole.” Butler recalls. The new South Pole seismic station performed as planned. “It turns out, when you get away from the noise that’s in a certain frequency band, the South Pole is actually the quietest place on the planet. I’m really proud of how it all panned out and how we were able to install the equipment that is still operational today.” The US Geological Survey and ultimately the Advisory Committee on Antarctic Names were also proud of Butler’s accomplishments, and in 2004 named a mountain after Butler, seen above in his office at UH, has helped install and operate seismic monitoring technology in extreme places—along undersea cables and even at the South Pole, where he helped place an observatory a thousand feet deep in the ice, one that remains operational today. For his achievements, the US Geological Survey named a mountain in west Antarctica for him.
Butler Summit rises to about 3,300 feet in western Antarctica. Another part of the planet that doesn’t have nearly enough seismometers is the ocean floor. Despite being one of Butler’s top priorities and a focus of his advocacy, it’s an area with many challenges and few solutions. Due to the extreme installation cost and the difficulty of effectively and affordably monitor the vastness of the sea bottom, where many of the largest earthquakes occur. During his time with IRIS, Butler was involved in a project funded by the Japanese government to repurpose a retired AT&T undersea telecommunications cable between Guam and Japan as a submerged seismic observatory. It succeeded in producing data for the region, but the rest of the world’s oceans were still unmonitored. “After working on the cable project with our partners in Japan, we decided to try and do one of our own,” Butler says of the project that ultimately brought him to the Islands starting in the late 1980s. “We said, ‘Let’s do something between California and Hawai’i.’”

At the time, AT&T was retiring one of its five undersea cables that run from Hawai’i to the Mainland, and Butler was able to help arrange for AT&T to donate the Hawaii-2 cable for use by the scientific community. “We picked up the cable and connected up a junction box to plug in things like seismometers, hydrophones and temperature gauges,” Butler says. “So we were able to create a seafloor observatory at the bottom of the ocean between Hawai’i and California, almost three miles deep.”
The Hawaii-2 Observatory, or H2O, remained operational for more than five years, providing critical Pacific Ocean seismic data before being retired in 2003. Since then Butler has remained involved in efforts to leverage other aging telecommunications cables or outfit new cable deployments to improve seismic monitoring in the ocean. “But we still have a long way to go,” he cautions. “Most of our seismic data comes from land-based stations, but to really improve our understanding and develop more accurate models, we need to have a more even global distribution of sensors. The only way we’ll get there is by adding more undersea monitoring.” In his lifetime, Butler hopes to make an impact in this specific area so Earth can be more accurately monitored for generations to come.

Whether actively monitoring, managing or simply doing the math, Butler and his colleagues at UH are on a constant search for new and innovative ways to improve the measurement and analysis of Earth’s vibrations. While seismometer readings near the epicenters of earthquakes typically provide the majority of information, and more undersea sensors are being developed, a few lesser-known data points have jogged Butler’s interest. For example, one of his passions is information about the structure of Earth’s core that can be extrapolated by studying antipodal reactions triggered by earthquakes occurring on the exact opposite side of the planet. “It’s really interesting when we have a quake where one of our seismic stations is on the other side of the globe,” Butler explains. “Because observing the movement at the antipode, on the other side of Earth from the epicenter, helps us determine the properties of the materials the waves are passing through. Is it liquid? Molten? Crystaline? What is it made of?” Earth scientists can study the patterns of seismic waves moving through the earth from one side straight through to the other side. “It’s like you’re bouncing rays off of things, like a dolphin, to let you basically see inside of the earth.”

With such insight into how seismic activity can illuminate Earth’s attributes, and because of his experience managing the GSN, it’s no surprise that Butler was tapped to assist NASA for the Mars Insight mission. “I was the seismologist on the NASA review team that monitored the project for years, making sure we properly implemented the seismology on Mars,” Butler says. By analyzing seismic activity on Mars, planetary scientists have been able to learn much more about the red planet’s structure. “They’ve found that the core of Mars is bigger, relatively speaking, than Earth’s core, and they’ve gathered data that helps scientists understand similar activity on Earth. “We live on a planet,” Butler explains. “So it’s helpful to understand the structure of another planet.”

Although he’s spent time studying seismic events in extreme locations, from remote islands to ocean trenches to polar ice caps and even other planets, the quakes Butler is most concerned about happen closer to home in expected locations but with unexpected strength. The 1946 Aleutian quake causing the tsunami that hit Hilo was big, but nowhere near as big as some other earthquakes throughout history. In 2011 a 9.1-magnitude earthquake shook the Tohoku region of eastern Japan, causing a tsunami that resulted in catastrophic destruction and loss of life. Coastal measurements from that event showed tsunami impacts on sea levels across the Pacific Rim and as far away as Antarctica, French Polynesia, Chile, the Galápagos Islands and even the east coasts of Africa and Europe. While earthquakes of that size are extremely rare, even Tohoku was dwarfed by the Great Chilean earthquake of 1960. At a magnitude of 9.5, that event holds the record for the strongest earthquake in recorded history. Hilo was devastated yet again by the resulting tsunami.

These earthquakes struck in areas known to be seismically active. There’s a history of patterns and data that can help emergency planners prepare for future events. But what happens when earthquakes we think we’re prepared for hit harder than expected? “When I looked at the pictures coming in from Tohoku and saw the size of the inundation zone, I thought, ‘This is terrible,’” Butler recalls. “Their defenses may have been able to withstand an eight, but they got a nine. Being in Hawai’i, I wondered, can we be wrong here?” Butler realized that Hawai’i had modeled its inundation zones based on the largest historical earthquakes that caused local tsunami events, like the 1946 quake. “But that was only 8.6, and we now know that something more powerful is possible,” Butler says. “If another, bigger earthquake happened in the Aleutian Islands, and I mean big—like 9, 9.5, as big as we’ve seen in other places on the planet—it could exceed our assumptions about inundation zones. It would be hard not to.”

After the Tohoku quake, Butler began working with Hawai’i’s Civil Defense and Emergency Management Agency to reevaluate and redefine tsunami inundation and evacuation zones to better prepare for more extreme events. “There’s a really good working relationship and respect for each other between the state and county and the Pacific Tsunami Warning Center,” Butler says. The collaboration is making a difference that could help save lives someday: “It’s a diverse group of organizations, but we all have the same goals. We all live here, we care about the people and we want to make sure that Hawai’i is well prepared.”
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