U.S.

Artificial Intelligence Helps to Decode Mysterious Earthquake Swarms

Seismologists use software to uncover complexity of fault systems; work could yield insights into how earthquakes originate

A strong earthquake in Croatia on March 23 caused widespread damage, injured more than 20 people in the capital, Zagreb, and was followed by a series of aftershocks.

PHOTO: DARKO BANDIC/ASSOCIATED PRESS

MY CONTRIBUTION:
For this article I produced the map and two scatter plots. The map was created in QGIS and fine-tuned in Illustrator to match WSJ style. The plots were both developed in an Observable notebook with D3.js and pulled into Illustrator to be cleaned.

Live link:
https://www.wsj.com/articles/artificial-intelligence-helps-to-decode-mysterious-earthquake-swarms-11592998200

By Daniela Hernandez / Graphics by Sawyer Click and Alberto Cervantes

June 24, 2020 7:30 am ET

In 2018, seismologists at the California Institute of Technology got several emails asking about a flurry of small earthquakes near Cahuilla in Southern California. What was going on underground? How long might the tremors last?

The scientists started looking at data streaming in from satellites, plus a variety of sensors that measured earthquake intensity and the deformation of the earth's crust, according to Elizabeth Cochran, a U.S. Geological Survey seismologist working with Caltech. The initial analysis came up empty.

Earthquakes in the Region, 2016-19

Earthquake epicenter occurence

Fault

Source: Zachary Ross, California Institute of Technology

That is when Zachary Ross, a Caltech seismologist who specializes in applying artificial intelligence to earthquake data, decided to input the measurements into an AI algorithm he had written.

The software yielded one of the most detailed descriptions to date of so-called earthquake swarms—unpredictable strings of quakes, often low-intensity—across time and space.

The analysis, described in a study published this month in the journal Science, could help scientists better understand the complex set of dynamic processes underground that culminate in earthquakes, seismologists said.

The earthquakes people are most familiar with, including Tuesday's 7.5-magnitude quake off the Pacific coast of Mexico that rattled the country's capital, happen when two tectonic plates slip past each other.

The Makings of an Earthquake Swarm

As fluid fills a fault zone, it makes it easier for slabs of rock to slip.

1. The rock in the fault zone is porous, like a sponge
2. At the base, there is an underground reservoir of fluid that's initially sealed

3. A crack allows that fluid to seep into the fault
4. The fluid acts as a lubricant that makes it easier for the fault to slip

Source: Science Magazine

In reality, that explanation is an oversimplification of what is happening beneath our feet, said Angela Chung, an earthquake early-warning system project scientist at the University of California, Berkeley's Seismology Lab. The behavior of fault zones, where earthquakes originate, is much more complex, but researchers still have little insight into the geological processes that give rise to that complexity, she and other experts said.

Unlike aftershocks—events following a single large earthquake that decrease in frequency and intensity with time—swarm activity is usually very erratic. Scientists often describe swarms as mysterious and elusive. Each one is unique.

They tend to happen where the ground is warm—near volcanoes, for instance. The consensus is that earthquake swarms are a byproduct of other geological processes, scientists said, including the movement of water, magma or gases underground and aseismic slip, the creeping movement of faults too slow to cause shaking.

"It's not really clear why [earthquakes] happen exactly," said Dr. Chung, who wasn't involved in the swarm work. "It can be a useful step to understand what starts an earthquake sequence."

The Cahuilla swarm described in the Science study originated along a 330-foot cracked region roughly 5 miles below the surface and 9 miles from one of

California's major fault zones.

SHARE YOUR THOUGHTS

Have you experienced an earthquake? Share your story below.

The swarm started in 2016 and lasted roughly four years, radiating out from this original spot to extend over an area of roughly 6 square miles. Its duration was far longer than other swarms recorded with modern tools, the authors said.

Where the Cahuilla Swarm Spread

The swarm started in 2016 and lasted roughly four years, radiating out from an initial point (red) to extend over an area covering roughly 6 square miles.

Source: Zachary Ross, California Institute of Technology

A fracture in the porous rock below allowed an unknown fluid—perhaps water or a gas—to migrate up and fill in the gaps, as water fills the holes in a sponge, Dr. Ross said. The fluid, which migrated along the fault zone, acts as a lubricant that makes it easier for adjacent slabs of rock to slip past one another. When they do, that generates earthquakes. The larger the slip, the bigger the quake's magnitude.

Dr. Ross's AI system scanned earthquake recordings, logged the time the temblors occurred and pinpointed their locations. The software detected more than 22,000 earthquakes ranging from magnitude 0.7 to 4.4. They were mostly tiny and imperceptible, both to humans and less-sophisticated methods of analysis, according to the authors.

"These smaller earthquakes are happening all the time, which means they're filling in gaps between all the larger ones," said Dr. Ross. "It's connecting the dots better."

Underground Cross-Section of the Cahuilla Swarm

A fracture in the rock allowed fluid to migrate up (injection point). Less fluid flowed into sections of the rock that were less porous, decreasing the chance of earthquakes (barrier zone).

Note: The horizontal and vertical axes are not proportional.
Source: Zachary Ross, California Institute of Technology

That is important because seismologists don't fully understand the geological

recipe of events that leads to large earthquakes.

"Every time there's a large-magnitude earthquake....they always seem to surprise us," said Alicia Hotovec-Ellis, a volcano seismologist at the USGS's California Volcano Observatory, who studies volcanic earthquake swarms but wasn't involved in the new study. "Being able to resolve some of these heterogeneities in the fault structure and places where slip is allowed to happen might be really useful in trying to anticipate what shaking might look like for earthquakes in the future."

The use of AI in seismology is still new, but interest is growing, scientists said. The researchers plan to study other previously recorded swarms to understand how long they last and what geological events caused them.

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Zero Waste, Zero Chance

New York wasted enough to fill its landfill contribution twice in 2019. Only 3 cities in the US produced more trash per capita.

We can do better.

WE COMMISSIONED
Global Research Partners to conduct the research for this project. There were around 1 million people living in Manhattan, Brooklyn, Queens, Staten Island and Bronx.

GO ON
https://zero-waste.com/

New York is trying to live its life as the trash capital of the world by going zero waste. Can the city do it? Can it do it in time?

Over the past few years and years, the city has demonstrated a lot the way through the implementation of waste management initiatives for residents and businesses. Yet, the city's 2019 waste data, which is the most recent data in terms of waste, the city has confirmed a difference that its initial plans in the world has succeeded at - going zero waste, meaning the city has succeeded in its goal.

But since that ambition was conceived, quite a lot has changed. Some roads, according to an analysis of the Department of Sanitation's monthly tonnage data, have been bumpy. Yet, the city's 2019 waste data shows that its contribution has dropped and continued to drop over the length of more than 5000 tons of daily consumption.

Recycling and waste production in 2019

- Recycling
- Waste

The management of 11 million people, 3 million tourists and 500 million visitors in 1986. The local government had grown from 2 to 5 per cent. Yet, the city's waste data shows that it has been able to reduce its waste production. It has decreased its waste production by 5 per cent, which is a significant reduction in the amount of waste produced by consumers.

A similar trend emerged in the Bronx, where the tariff contribution has only inched down 3% since 2009. The Point in the side of New York's zero waste dreams is that the city's waste production has dropped by 5 per cent, which means that New York, through the planning and policies in place, has contributed to a better benefit or information to handle the waste. Each year the city drops off its garbage to the landfill, the city's waste data shows that it has been able to reduce it. In the fiscal year 2019, the tonnage was the city's lowest ever, at 1.1 million tons, or 1 million tons per year.

Yet, the data shows that the city has achieved the diversion rate, the rate at which waste is diverted from the landfill through programs like recycling. The city's recycling rate goes from 20% in 2009 to 21% in 2019, according to estimates. Although the city's waste data shows that it has been able to reduce its waste by 20% in a different time period of consumption, residents produced 800 lbs of trash per person in the fiscal year, or 2 lbs. Yet, from the Fiscal year 2019.

At this rate, the city will not hit its zero waste goal by 2030.

Since you opened this

1 in 5 people

pounds of trash has been discarded

These neighborhoods - which make up about a tenth of New York City's population - produced 1.1 million tons of trash, or 1 million tons per year, in 2019. Annually, New Yorkers produce more than 2 million tons of trash and recycling, according to a 2016 study of waste firms in the world's largest cities.

More than 70% of that goes to landfills, to incinerators or to waste, making New York the greatest producer of trash in the world. But New York doesn't have a landfill in its city limits, so it ships its trash to other states. The city's waste data shows that it has a different time period of consumption. residents produced 800 lbs of trash per person in the fiscal year, or 2 lbs. From the Fiscal year 2019.

At this rate, the city will not hit its zero waste goal by 2030.

Recycling changes

- 1 person
- 1 pound
- 1 pound
- Cost to Recycle

"These community outreach programs have been successful and account for much of the city's change, but the initiatives aren't potential at the city's change."

CENSY targets neighborhoods with historically low diversion rates, and it has a dedicated team of language speakers, according to Espinosa.

"Target poverty was tailored was poorer than city."

Each of these 29 districts increased its diversion rate, and most are altogether thriving away now.

But when it came to districts that are recycling less, the first three districts were in Lower Manhattan, Staten Island and Brooklyn.

Four of the five districts are significantly more affluent than the rest of the city, according to Census income data.

"Hugh Lorne defended a decision to hold a meeting in Staten Island's 2019 when the first two cities of Brooklyn and the Bronx.

Manhattan's community districts (ranks 1, containing Wall Street, Old Greenwich, Tribeca, Tudor City, Chelsea) Park and Hoboken - recorded the greatest drop with a little more than a 10 percentage point, equal to thousands of tons of waste.

They're also extremely wealthy, with median incomes of more than $100,000, more than twice that of the city.

IN THE DARK

The Department of Sanitation has based most of its monthly reports on estimates, and it has been difficult to get a clear picture of what residents are throwing away, according to the Department's head, Kate Gilmore.

Moving forward, the budget calls for an increase in funds allocated for outreach and enforcement specifically to target the worst zones in violation of zero waste laws, as the Fair districts with diversion rates. Here, these events are waiver in affiliate with the Department of Sanitation, and the Department of Sanitation, which is responsible for collecting and disposing of the city's waste.

Occasionally, CENSY will hand an event that's more in the spotlight, other hold in Brooklyn's Bushwick neighborhood, which is home to a large Latin community. Attendees are given with a massive event in Union Square. The event has been typical a shelter away, recycling channeled gentes, bicycle repair, Zoodoo rolls on Zoodoo and Zoodoo.

In school, Espinosa's community, Jackson Heights, is a Latin community, and it's a sector in diversion rate, it's religious, district, Latin's, still based were.

To clarify, these weekly distinctive events are not the largest diversion rate in the city. Generally, the weather is a district, to the more that is recycles. But over the last few years, the Department of Sanitation has been conducting outreach in neighborhoods has expanded their campaign to curb, while diversion rates in less affluent areas have been the most. Yet, the city's waste data shows that it has been able to reduce its waste.

Recycling rate changes ranked by 2019 rates

Bronx Brooklyn Manhattan Queens Staten Island

2009/2019 recycling rates

0% 10% 20% 30%

The Department of Sanitation recognized in the 2018 status report that it would have to take more steps to reach its goal of zero waste by 2030.

New York's City Council declared in June 2018 that the city was in a state of climate emergency. The city's waste data shows that it has been able to reduce its waste in a different time period of consumption, residents produced 800 lbs of trash per person in the fiscal year, or 2 lbs. From the Fiscal year 2019. The city's waste data shows that it has been able to reduce its waste.

In the more than a thousand landfills, recycling, distraction, recycling and waste, residents produced 800 lbs of trash per person.

The economy must shift from ultra-energy-intensive production to a more regenerative or energy democracy that benefits our people, environment and a clean, renewable energy economy. Our goal is to create a new economy that is more equitable and inclusive and protects the most vulnerable from climate-fueled disasters in that sweepings. Form our dependent ground and destructive unbelievable growth in the economy, and instead, we must create a new economy that is more equitable and inclusive and protects the most vulnerable.

The actual collection, recycling, distraction, recycling and waste, residents produced 800 lbs of trash per person.

ENVIRONMENTAL INFLUENCERS

Nicole Crowdsong, the Bronx Recycling Coalition's director, is one of the city's further in a given. Officially, and it's a bronx, and it's belonging to the city's 63 million residents.

Crowdsong, who's been with the coalition since 2009, has educated about the city's waste and recycling problem for years. Her goal is to make it easier for the city's people - and of all the kind - refuse. Crowdsong, a Bronxy New Yorker and a project manager for the Bronx Recycling Coalition, is a Bronx native. She's lived and bronx in education and recycling.

After a layoff in summer 2018, Crowdsong, an Astoria resident, shifted to freelance work. She let her subject focus shift to where she worked closely with clients in the Bronx, Brooklyn and Queens, and Staten Island.

"I always keep pointing it off here that I feel like the universe was pinging me that deeper along the way," Crowdsong said. "I knew I just felt it in the layoff as a sign from the universe that at that point was second, screaming at me to follow my passion and do what I was meant to do, which was to do this work."

It was Goldfinger, and she realized that the work she was doing was a mix of management and organizing. But she wanted to do more. She knew if the city wanted to reach its goal of zero waste by 2030, it would need to do more than just the bare bones, she dreamed of holding the mayor's feet to the fire and pushing for change.

She had called Berkey Solly becoming zero waste, recycling waste billing, and recycling waste billing, and recycling waste billing, and recycling waste billing, and recycling waste billing, and recycling waste billing.

In August 2019 Berkey Solly joined the Bronx Recycling Coalition as a senior fellow. Fellow seeking to the change she started to seek. The star founded Zero Waste Chance, a nonprofit that aims to help people, organizations and businesses become members on the Greens.

Right off the bat, they carried with the Department of Sanitation's nonprofit. The Department of Sanitation's nonprofit, Zero Waste Chance, is a nonprofit that aims to reach zero waste. The foundation aspirations to "reduce waste and promote greener forward promoting environmental sustainability, including Nation's steps, beach cleanups, and environmental education."

The coalition's mission is to "reduce waste and promote greener forward." Berkey Solly, with the goal of developing an urban resort initiative. Everybody want to make a substantive difference, it seems and crowdsong Solly, Crowdsong said.

In February, the Workshop Series started with the Foundation as a part of the city's Zero Waste Chance initiative. The Workshop Series, which is a part of the Zero Waste Chance, Foundation's Zero Waste Chance initiative, is a part of the city's Zero Waste Chance.

Additionally, Crowdsong said her audience is primarily made up of those who have an interest in the environment and sustainability, and that's a good thing. "We are all in the city's diversion numbers. Crowdsong estimates that there are about 1,000 people.

Crowdsong said the Bronx Recycling Coalition's mission is to "reduce waste and promote greener forward."

CORONAVIRUS

The yachting crowd was gearing up for a booming 2020 sailing season. Then the coronavirus happened.

The Bahamas deployed warships to enforce its port restrictions, one of several new hindrances to a big boat lifestyle.

——— David Geffen's yacht, the Rising Sun, is more than 450 feet long. It has another yacht, Rising Sun Car, that docks inside.
Gregory Rec / Portland Press Herald/Getty Images File

Mar 9, 2020, 7:46 AM CDT

By Sawyer Click

MY CONTRIBUTION: I fully reported and developed this piece as an intern on NBC News Digital's data and graphics team. It's the most recent piece I did for the data graphics team. The annotated map was first developed in Observable and then re-created in regular JavaScript using Scrubber to animate through dates. The line chart was created using D3.js and d3-ieg annotation.

Live link: https://www.nbcnews.com/news/us-news/yachting-crowd-was-gearing-booming-2020-sailing-season-then-coronavirus-n1200239

If you were one of the lucky Americans to own a yacht before the coronavirus shut down the country, you were probably on the water.

In the first three months of the year, the average yacht sailed farther than the year before, according to an NBC News analysis of MarineTraffic boat-location data of 514 U.S.-flagged yachts at least 90 feet long.

For the billionaire David Geffen, that meant sailing around the South Pacific on Rising Sun, his longer-than-a-football-field superyacht, which includes another boat, the Rising Sun Car, which docks inside. Like-minded superyacht owners followed suit, ditching the perils of sheltering at home — customer limits at grocery stories and trading designer clothes for toilet paper, among other struggles — for life at sea.

But after President Donald Trump declared a national emergency on March 13, ship travel plummeted. What looked like a big season ahead for the yachting crowd turned anything but as the coronavirus spread, shelter-in-place orders were issued and island coastal borders were tightened.

Anchors down

Superyachts started sailing back stateside in the wake of the coronavirus pandemic.

Superyachts are generally at least 90 feet long, according to several superyacht club managers in Florida. The vessels typically have a paid crew on board and come with multiple bedrooms and lounging areas.

"You know it when you see it," said Enrique Quintero, the general manager at the superyacht club Prime Marina in Miami.

For superyacht owners, the go-to spots before the national emergency declaration were the Florida Keys, the Bahamas and the Caribbean: paradises that had little-to-no confirmed coronavirus cases and were still mostly open. Yachting season for the region was at its peak for the year, with nearly 65 superyachts stretched throughout the region. After Trump's declaration, four-fifths of the ships set sail for the U.S. At the same time in 2019, there were three times as many U.S.-flagged yachts in the Caribbean.

As states began to issue stay-at-home orders and the country ground to a halt, the yachting season became less about leisure and more about finding somewhere to shelter in place.

Superyachts head home

In the weeks following Trump's declaration of a national emergency, four-fifths of the superyachts in the Caribbean sailed to the mainland U.S.

Source: NBC News analysis of MarineTraffic ship data.
Graphic: Sawyer Click / NBC News

"A lot of people had that idea that, 'Oh, I'm going to jump on my boat'"

Phil Brassington, a Florida-based shipwright who specializes in long-term sailing equipment, has worked late nights and weekends since February to keep up with increased customer demand. Though some of his customers made it to sea, several puttered out around the Keys, stuck stateside because of travel restrictions. From yacht shipwrights to yacht salesmen, work in the industry has picked up as affluent customers come calling.

"I've been very busy, because as COVID-19 unfolded, a lot of people had that idea that, 'Oh, I'm going to jump on my boat and leave,'" Brassington, who has lived with his wife and two children on their catamaran for the last few years, said.

Related

These states have the most coronavirus cases. See the day-by-day breakdown.

COVID TRACKER

Among those eager to escape the pandemic was Brian Harmon, 57, a retired restaurateur and chef. As coronavirus case numbers began to ramp up in mid-March, Harmon made plans to leave the mainland on his catamaran, Salty Dreams.

"I was not going to participate in the insanity," said Harmon, who lives on Florida's mainland when he's not sailing. "So I decided that I thought the best way to a quarantine would be to hop aboard Salty Dreams and get off land."

——— David Geffen's yacht Rising Sun at dock in Portland, Maine, in 2013.
Gregory Rec / Portland Press Herald/Getty Images File

Within a week he had built a crew solicited from an online sailing forum and had cast off for the Florida Keys. In the weeks since, he's spent most of his time fishing, tinkering with the boat and watching "Peaky Blinders"on Netflix when there's an internet connection. His crew consists of a married couple from upstate New York in it for the experience. The wife, an attorney, works by phone whenever she can and the husband is often away on Harmon's dinghy exploring.

In mid-April, after a month or so at sea, Harmon was out of groceries and had to turn around as popular islands in the Keys restricted travel. At Key West, the dockmaster held onto Harmon's driver's license while he debarked for an hour to get gas and groceries. At Marathon, he wasn't allowed to leave his boat at all. The inconsistency and lack of freedom drove him to turn Salty Dreams around for a slow-paced float back to mainland Florida.

Despite droves of boats such as Salty Dreams sailing home, yacht salesmen are keeping busy, according to Michael Costa, a salesman based in California. His company, SeaNet, deals in selling whole yachts and shares of yachts, akin to a timeshare.

In the past few weeks, he's seen an increase in families drawn to the fractional ownership program, which has a price tag starting at $250,000. Most customers, Costa said, are interested in weekend getaways.

"I think that people are looking at private yachting as a very interesting alternative in this environment," Costa said. "People are rethinking their vacation trips to Europe or having to travel long distances as it relates to getting on a plane."

Ports close, add restrictions

Most islands in the Caribbean, such as the Bahamas and the U.S. Virgin Islands have implemented restrictions similar to those in the Florida Keys, allowing few ships out and fewer in. Yachters have been left with two options: shelter-in-place until the waters open or retreat stateside.

The island clusters are gathering spots for a majority of superyachts outside the U.S. After seaports began closing in the Florida Keys in late March, many superyachts set sail toward islands in the Caribbean, which started closing soon after.

Bahamian Prime Minister Hubert Minnis sent in warships from the Royal Bahamas Defense Force in early April to prevent unauthorized ships from traveling the islands without written permission.

For Katie Gasper, 39, who has been living at sea for years with her husband and 11-year-old son aboard a 65-foot yacht, the crackdown meant staying put.

Gasper, a former physician assistant and current stay-at-yacht mom, and her family were in the U.S. Virgin Islands in mid-March, a day after the Islands confirmed its first coronavirus case. If it weren't for prior docking reservations, the family wouldn't have been allowed in.The island's shelter-in-place rules are similar to those stateside: Nonessential businesses have temporarily closed, restaurants are limited to takeout and delivery, and gatherings of more than 10 people are prohibited.

Related

Map of how many coronavirus cases have been confirmed across the country

COVID TRACKER

They're still allowed to travel on land throughout St. Thomas, but the limitations have started to bite at their day-to-day schedule. Since March, their typical day isn't that different than before the pandemic: biking, homeschooling, board games and yoga. Gasper said the most uncomfortable difference is the lack of human contact.

"We don't really hang out with people," Gasper said. "Drinking at sundown is a really big thing for sailors. We've done it only once in the past three or four weeks with friends of ours that are an older couple. We just sat 6 feet apart from each other on the dock getting drunk."

The Gaspers are staying put until further notice, postponing a loosely planned trip that would have taken them through the Panama Canal and toward Australia, where Gasper's husband dreamed of staying for a few months. She said the family feels safer docked in the islands than they would stateside, largely because of the distance between themselves and coronavirus hot spots.

The port they're docked in, Charlotte Amalie, had been crowded for weeks, Gasper said. But after the island's social distancing measures went into effect, the superyachts cleared out and headed for Florida's beaches, which Gov. Ron DeSantis opened portions of two weeks later.

"It was kind of just like business as usual here," Gasper said. "A lot of the megayachts were coming and going and partying. Now many of the boats are returning to the U.S. prematurely. They're either sailing up there or being shipped on freighters up there. It's emptied out quite a lot."

——— Sawyer Click

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