BUYING TIME

The U.S. Is Building an Early Warning System to Detect Geoengineering

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By Christopher Flavelle

Christopher Flavelle reported this story from Boulder, Colo. and Albuquerque, N.M.

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In a guarded compound at the foot of the Rockies, government scientists are working on a new kind of global alarm system: One that can detect if another country, or maybe just an adventurous billionaire, tries to dim the sun.

Every few weeks, researchers in Boulder, Colo., release a balloon that rises 17 miles into the sky. Similar balloons are launched with less frequency from sites in Alaska, Hawaii and New Zealand; Reunion Island, near the coast of Africa; and even Antarctica. They make up the building blocks of a system that would alert American scientists to geoengineering.

As the planet continues to heat up, the idea of intentionally trying to block solar radiation — sometimes called solar radiation modification, solar geoengineering, or climate intervention — is gaining attention. Governments, universities, investors and even environmentalists are pouring millions of dollars into research and modeling of geoengineering systems.

It could be a relatively quick way to cool the planet. But it could also unleash untold dangers.

Many worry that solar geoengineering could have unintended consequences, shattering regional weather patterns and damaging everything from agriculture to local economies. And the first steps could be done quietly, by a rogue actor or another nation operating without any regulations or controls.

So the United States is building a system that would allow it to determine if and when others may be trying to tamper with the Earth's thermostat.

A map showing the balloon's possible trajectory based on wind speeds of different days, left. Retrieving a balloon in the Pawnee National Grasslands in Colorado.

“It’s some of the most important stratospheric science going on in the world today,” David W. Fahey, director of the National Oceanic and Atmospheric Administration’s Chemical Sciences Laboratory, which is building the network of balloon sentries, said on a recent afternoon in his office in Boulder.

Both NOAA and NASA have satellites that can detect large quantities of aerosols in the atmosphere but they can’t pick up smaller amounts. That’s where the balloons come in. Each one carries a six-pound contraption, about the size of a lunchbox, filled with wires and tubes. The device measures tiny airborne particles, or aerosols. A jump could indicate the presence of an unusual amount of aerosols in the stratosphere, possibly to deflect some of the sun’s heat back into space.

Dr. Fahey’s team is building the capacity to detect, track and understand the effects of any unusual aerosol release.

The early warning system for geoengineering is an effort splintered across federal agencies and laboratories. NOAA has the device to measure aerosol concentration and raise a red flag at any anomalies. The National Aeronautics and Space Administration has the high-altitude aircraft that can carry sophisticated testing equipment to the location of an aerosol plume. Scientists at Sandia National Laboratories in New Mexico, working for the Energy Department, have a tool that can estimate when and where a burst of aerosol was emitted.

Researchers stress that these detection efforts are still in their infancy. As of now, they believe that solar geoengineering has only been attempted at a very small scale, despite the claims of conspiracy theorists.

But the work taking place at NOAA and Sandia demonstrates how geoengineering has morphed from the stuff of science fiction to a source of growing concern for the government.

"If a country — a major ally, or a major opponent — is building up capabilities, can our scientists tell us what they're trying to do, and what the impact of that would be?" asked Kelly Wanser, founder and executive director of SilverLining, a nonprofit group that advocates for geoengineering research and helped persuade Congress to fund NOAA's program. "How dangerous is that? How fast and hard do we need to respond?"

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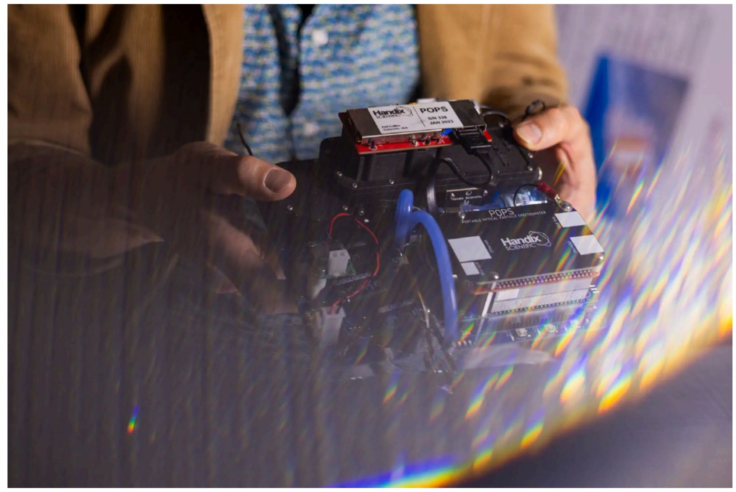
The chemical sciences laboratory that NOAA operates in Boulder has the feel of a college campus. Some of the world's top atmospheric scientists roam the halls in hiking boots and T-shirts, as if ready to hike up the Rocky Mountains that are visible through the windows. The only hint of the nature of their work are the armed guards at the gates, sweeping visiting vehicles for explosives.

Dr. Baron focuses on the microphysical properties of aerosols. Nina Riggio for The New York Times



The device his team is working on pulls air into an intake tube and scans it with a laser. The aerosols scatter the light, making it possible to record their concentration and size. Nina Riggio for The New York Times

In a windowless room, Alexandre Baron, a young French scientist who focuses on the microphysical properties of aerosols, displayed the innards of the boxes his team has been sending aloft. The device pulls air into an intake tube and scans it with a laser. The aerosols scatter the light, making it possible to record their concentration and size.

Once the balloons carrying the devices ascend to 90,000 feet, almost three times the cruising altitude of a passenger jet, a valve opens to slowly release helium and cause the balloons to drift back to Earth. The round trip takes three and a half hours, during which time the instruments send aerosol readings back to the ground by radio.

NOAA retrieves most of the boxes, which cost about $15,000 a piece, replacing components so they can be used again. (The agency has lost some of the balloons over the ocean and in the Alaskan wilderness.)

Sometimes a balloon and its precious cargo get tangled in trees. Leaning against the wall in Dr. Baron’s room, among laboratory equipment, was a large tree pruner. “I definitely used it on one occasion where the payload was strung up,” said Troy Thornberry, the NOAA research scientist in charge of the program.

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The immediate task of the scientists in Boulder is to gather enough data about aerosol levels at different spots above Earth to create a base line of normal concentrations, absent some outside event like a volcanic eruption. That would allow NOAA to determine when aerosol levels at any particular spot are unusually high.

The program, which Congress began funding in 2020, fits within NOAA's broader mission to study the atmosphere, Dr. Thornberry said. The budget is less than $1 million a year, he added.

Troy Thornberry, the NOAA research scientist in charge of the surveillance program. Nina Riggio for The New York Times

Richard Querel, an atmospheric scientist who runs the balloon launches out of New Zealand, left, with atmospheric technician Penny Smale in preparation for a launch from Lauder, New Zealand. Tatsiana Chypsanava for The New York Times

To build a global base line, NOAA has been working with researchers and government scientists in other countries. It is coordinating launches with researchers in Réunion, a French territory near Mauritius. This month, NOAA staff launched a balloon for the first time from Suriname, a small country on Brazil's northern border, with plans for future launches run by that country's meteorological agency. NOAA plans to visit Palau, a small island nation between the Philippines and Guam, early next year, seeking a similar arrangement.

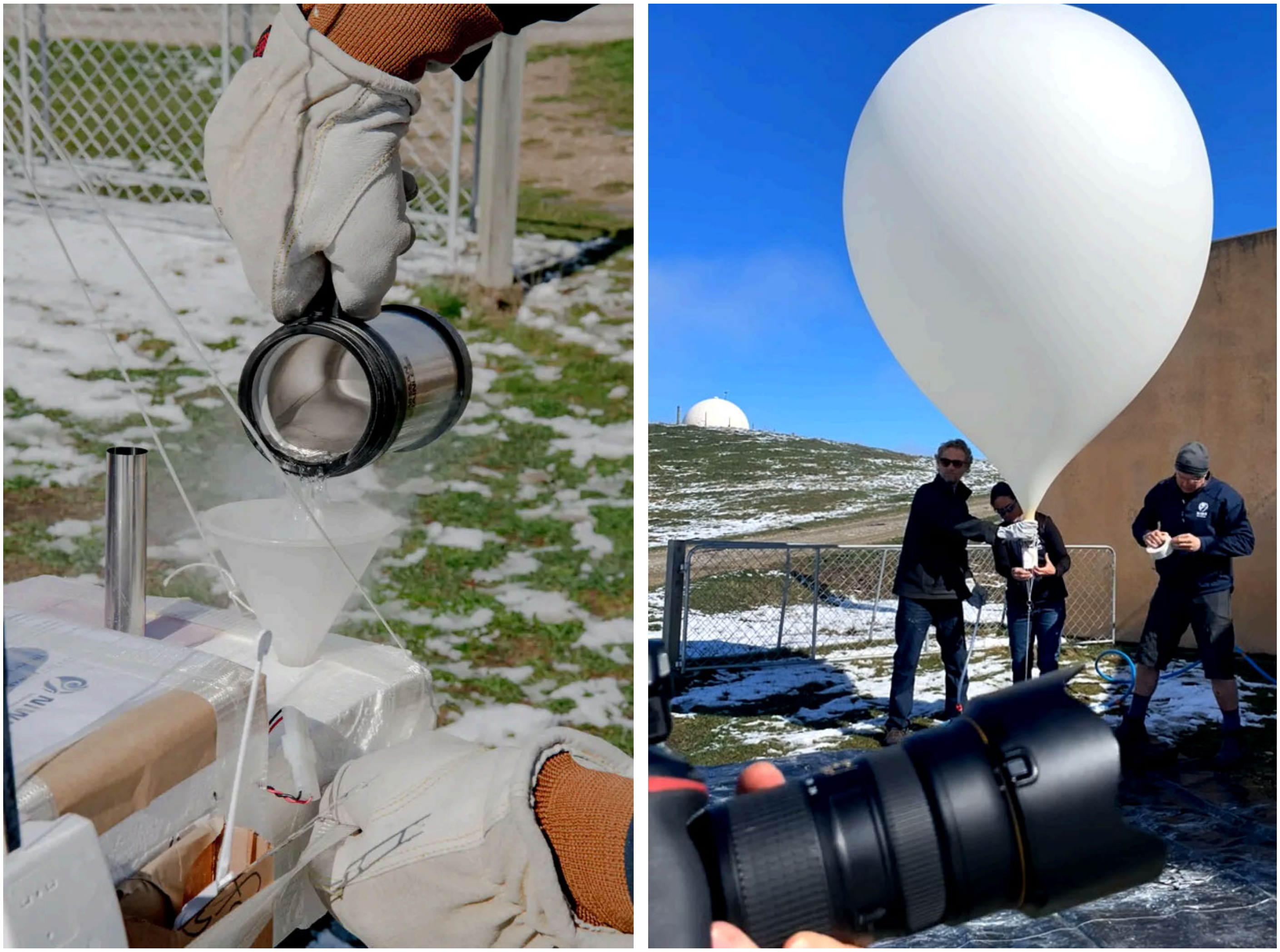
When balloons are launched in other countries, NOAA’s partners relay the data to be analyzed in Boulder. They also have access to the data, which is shared publicly.

There is no payment involved, just an ethos of collaboration and mutual assistance among atmospheric scientists, Dr. Thornberry said. Also, the effort required to launch the balloons is minimal, he added. “All of the little pieces are seen as contributing to the advancement of the whole,” he said.

Richard Querel, an atmospheric scientist and group manager at New Zealand’s National Institute of Water and Atmospheric Research, which runs the balloon launches in that country, said working with NOAA “allows us to expand our suite of observations beyond what would be possible to do on our own.”

The United States wants to establish regular balloon launches from seven sites around the world and maintain those launches for three to five years, Dr. Thornberry said. At that point, the agency should have enough information to confidently identify unusual increases, he said.

Dr. Thornberry said he’s not aware of any other countries pursuing a similar surveillance effort. “Maybe because they just don’t talk about it,” he added.



Liquid cryogen poured into a frost point hygrometer ahead a recent launch in New Zealand, left. A timeplapse of Dr. Querel's team inflating their balloon.

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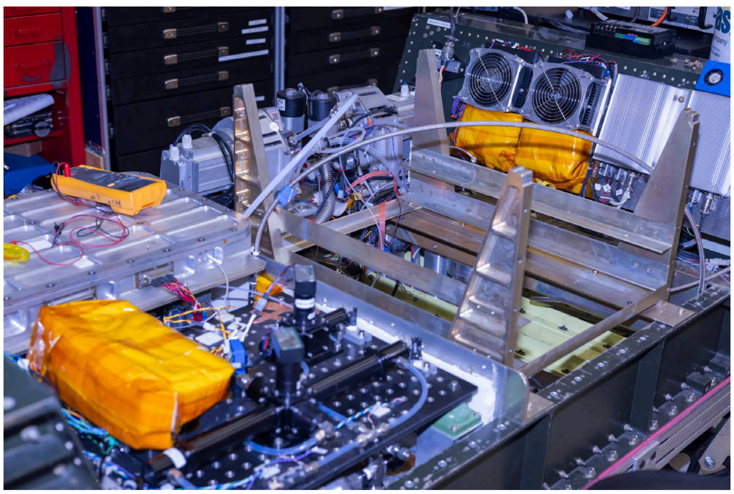
If the balloon system were to detect a suspicious level of aerosols, then Dr. Thornberry would turn to another instrument in NOAA's laboratory. It's the world's most sensitive device for detecting sulfur dioxide, the material most often cited as likely to be used to reflect radiation away from Earth. A bundle of valves and tubes that resembles a racecar engine, the instrument can measure concentrations as small as one part per trillion.

NOAA would load the device in the back of a truck, drive it to Houston, and bolt it to the bottom of a plane. But not just any plane.

There are only a handful of aircraft that can reach the stratosphere. One model is the WB-57, three of which are housed at NASA's Johnson Space Center. The plane, marked by a bulbous nose and extra-long wingspan, can fly above 60,000 feet.

Dr. Thornberry estimated that his team could get the device airborne within three weeks of detecting an aerosol plume and before it could dissipate. All that would be required is funding the flight time — somewhere in the range of $1 million to $1.5 million, he said.

A spokeswoman for NASA declined to make any of the agency's staff available for an interview.



The world's most sensitive device for detecting sulfur dioxide in NOAA's Boulder laboratory. Nina Riggio for The New York Times

NASA's WB-57 in a hangar at Ellington Airport in Houston. The plane can fly above 60,000 feet. Mark Felix for The New York Times

Some 400 miles south of Boulder, researchers at one of the country's pre-eminent nuclear weapons laboratories have worked out another part of the puzzle: how to identify the location of an aerosol release.

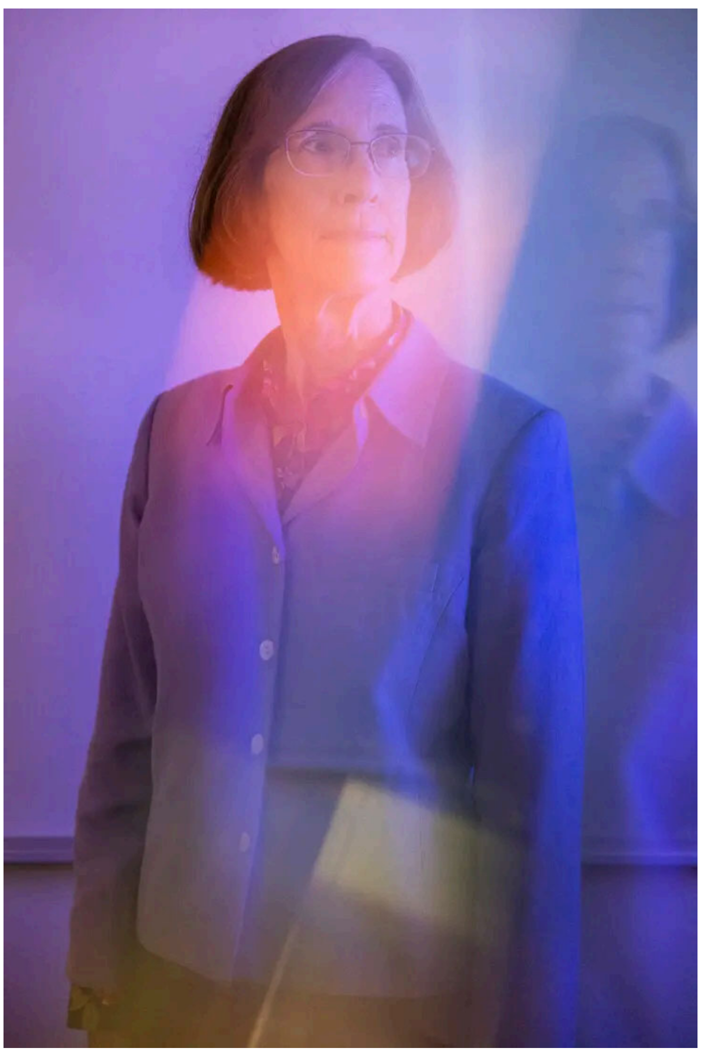
Sandia National Laboratories, on the eastern edge of Albuquerque, was started as part of the Manhattan Project, America's clandestine effort to build a nuclear bomb. These days the lab, which is operated by a subsidiary of Honeywell International under contract with the Department of Energy, has sophisticated computer-based models that can determine whether other countries are testing nuclear weapons.

Modern nuclear test ban treaties only work "because we would be able to know if Russia conducted the tests," said Erin Sikorsky, who formerly led the U.S. intelligence community's climate security analysis, and now directs the Center for Climate & Security, a Washington research group. "And it was the scientists at Sandia who developed the systems to be able to figure that out."

That capacity to build sophisticated detection models comes in handy in the age of solar geoengineering.

Laura Swiler, a senior scientist at Sandia, developed an algorithm that could take an observed aerosol plume from any source — say, a volcanic eruption, or a large wildfire — and look backward in time to estimate its size and point of origin.

It's a hard problem, Dr. Swiler said, because "the aerosol plume is moving."



Laura Swiler, a senior scientist at Sandia, left; Research scientists Patrick Cullis and Alex Fritz releasing a ballon from the NCAR Marshall Field Site south of Boulder.

The tool that Dr. Swiler created with colleagues Diana Bull and Kara Peterson is part of a program called CLDERA, pronounced “caldera” — the word for a crater formed by a volcanic eruption. The team used data from the 1991 eruption of Mount Pinatubo in the Philippines to build the algorithm and then test its accuracy.

That method was designed to examine any type of aerosol plume. If NOAA or NASA detected a spike in aerosol levels, Sandia’s algorithm could estimate the amount released and perhaps where it was released and when.

“We do have the capability, and it does tie strongly to something like an early detection system,” Dr. Swiler said.

The tool can also estimate the consequences of an aerosol injection, things like changes in surface temperatures, precipitation levels or soil moisture.

“The effect will possibly last months, and even maybe a couple of years, depending on how much aerosols they’re injecting,” Dr. Swiler said. “Understanding what might happen two years hence — that is where we will have to rely on our modeling capabilities.”

The United States is still years away from being ready to detect a solar geoengineering effort but is on the leading edge.

“We know more about important aspects of stratospheric aerosol as it exists today than any other group in the world,” Dr. Fahey said. “We’re playing the long game.”

Christopher Flavelle is a Times reporter who writes about how the United States is trying to adapt to the effects of climate change. More about Christopher Flavelle