

**FEATURES:** DIY Geoengineering

# HACK THE CLIMATE

*You can cool Earth — one balloon at a time*  
Written by Luke Iseman

Make Sunsets

**LUKE ISEMAN** is cofounder of Make Sunsets. He (very occasionally) writes at [lukeiseman.com](http://lukeiseman.com) and lives mainly around California (Baja and Northern).

It's easy to feel like climate change is too big of a problem for makers to tackle; I certainly felt this way. Yeah, adding solar panels to my RV felt good and helps a bit, but I'm still towing it behind my gas-guzzling F-450. Modern life emits a lot of carbon, and it's not stopping any time soon. Nor is warming: we've only experienced half of the heat we've already baked in with our past emissions. The more I learned, the greater my suspicion that global warming is too great a challenge for makers like me!

I turned to the wrong fiction for a distraction. In Neal Stephenson's *Termination Shock*, a Texan billionaire builds the biggest gun in the world to shoot sulfur dioxide into the stratosphere (20km up). He names it Pina2bo, after Mount Pinatubo. This one volcano released enough sulfur dioxide to drop the world's temperature by 0.5°C for 2 years. I cranked through the book and dove into the science.

The more I researched, the more empowered I felt. Sulfur is cheap and effective: \$200 buys you a ton, and if you can get it to the stratosphere it will cool Earth for a year as much as 2 million tons of carbon heats it (see [makesunsets.com/blogs/news/calculating-cooling](https://makesunsets.com/blogs/news/calculating-cooling)). Chalk dust works too; many other benign chemicals might also be used. But could I come up with a way to get these reflective clouds 20km up to do their job?

In April 2022, I decided to find out. I ordered a \$200 weather balloon and \$10 of gardening sulfur from the internet. I lit a pile of sulfur on fire and immediately regretted it: sulfur burns to make sulfur dioxide (just like in volcanos), and this reacts with water vapor to produce sulfuric acid. I was breathing small amounts of the liquid in car batteries!

After adding an acid vapor gas mask — and a lid to my burn pot — things got a lot less caustic. I used my trusty 5-gallon bucket vacuum to pump some of the smoke into my weather balloon, and my clouds were ready to deploy. A tank of helium and a few zip ties later, I was ready to launch. With a couple hundred dollars of supplies, I became the first person to intentionally cool earth from the stratosphere!

I decided to give myself until the end of 2022 and \$50,000 to convince others to work on this with me. If I couldn't, I'd stop before running out

of money or becoming completely obsessed, document my results, and move on with life. I proceeded to talk to many of the makers and founders I've met over the years, trying to get them to talk me out of this. Instead, the opposite happened. Three key things I learned:

**1. Nobody had a good reason why this shouldn't or couldn't be done.** Speaking with academics who had researched this for years, the only excuse they had for not having already done this was "politics." And the potential consequences? They pale in comparison to global warming: maybe a bit of ozone degradation, but in exchange the ability to drop temperatures by at least 0.5°C (and likely more). As a maker fond of breaking rules, with some room on my credit card and strong opinions on morality, this felt like a perfect project for me.

**2. Carbon credits are a big joke.** You know those "Click here to plant a tree and offset your flight" banners you see? Most of them result in 0 trees being planted, and yet this is a multibillion-dollar market. People are buying pretend action; this was a low bar against which to compete.

**3. Friend of friends help.** I'm not exactly what you would call outgoing, so I didn't love talking about my project to random people. But chatting with friends feels great. Fortunately, friends introduced me to their friends. Several awkward calls later, some of these became investors. I (and many of you!) should be more willing to ask for help and introductions; your friends might know the perfect supporters for your project. Mine certainly did!

It's been an exciting 2 years of geoengineering. I knew someone who enjoys selling as much as I like making; it took some convincing, but I got Andrew Song to join as my cofounder. (That's him shown launching the balloon.) We invented Cooling Credits: 1 Cooling Credit = 1 gram sulfur dioxide delivered to the stratosphere, which roughly offsets the warming from 1 ton of CO<sub>2</sub> for 1 year.

Andrew has sold these to 525 true believers, and we've launched 68 balloons to deploy 35,970 Cooling Credits. We've got a long way to go before

## FEATURES: DIY Geoengineering

we have a meaningful impact on global warming, but it feels great to have started something fundamentally new that needed to be started — a hot opportunity, you might say.

You probably have questions; much of the internet did, too. Tomas Pueyo did the most comprehensive write-up we've found, at [unchartedterritories.tomaspuoyo.com/p/so2-injection](http://unchartedterritories.tomaspuoyo.com/p/so2-injection).

And launching the balloons is fun, too. Here's how you can do it yourself!

## GET COOL

### 1. PLAN

Pick a day with minimal winds, definitely under 10mph, ideally under 5. Gather supplies and lay them out neatly (Figure A): knolling is never so useful as when you're trying to manage a 6-foot-diameter, easily poppable balloon.

Put in your launch location at Sondehub ([predict.sondehub.org](http://predict.sondehub.org)) to plan where your balloon is likely to go (Figure B). If you're in the U.S., notify the Federal Aviation Administration by calling them at (877) 487-6867, after reading the guide at [makezine.com/go/filing-a-notam](http://makezine.com/go/filing-a-notam).

### 2. PREP SUBSYSTEMS

Activate your Spot Trace subscription, make sure you're getting readings from your tracker(s), that it's easy to turn on lift gas, your scale works, rubber bands are not decayed from sun/age, and every part is attached and untangled. You can use our checklist at [makezine.com/go/so2-launch-checklist](http://makezine.com/go/so2-launch-checklist).

### 3. ADD CLOUDS

Weigh your empty balloon, add calcium carbonate (Figure C), and weigh again (Figure D). The difference is the weight of your clouds.

### 4. ADD LIFT GAS

This is a bit of an art. Even calm days usually have some wind, so you can't purely go by reading the balloon's pull on your scale. To get exact, you can use a bag of change or something that weighs more than your payload, but so long as you feel it pulling strongly upward, you're probably good.



## MATERIALS

- » **Balloon** The Kaymont HAB-600 is one of our favorites, with plenty of buoyancy for trackers as well as several hundred grams' payload. Just want to put up a few grams and don't care about tracking? Use any normal latex party balloon (latex biodegrades; avoid shiny, plastic Mylar).
- » **Reflective particles** Start with chalk dust (calcium carbonate) for your first several launches, such as Amazon B00GIIUZLY. Only move on to sulfur dioxide ([lindeus.com/gases/buy-sulfur-dioxide-gas](http://lindeus.com/gases/buy-sulfur-dioxide-gas)) with a proper acid vapor mask like 3M's OV/AG P100 Pro.
- » **Lift gas** Helium is safer and easy to find: [partycity.com/balloons-helium-tanks](http://partycity.com/balloons-helium-tanks). Work your way up to cheaper, lighter hydrogen; for repeat launches, you'll want a bigger tank from your local industrial gas supplier (or make your own electrolyzer!)
- » **Rubber bands** Size #6 work well.
- » **Electrical tape**

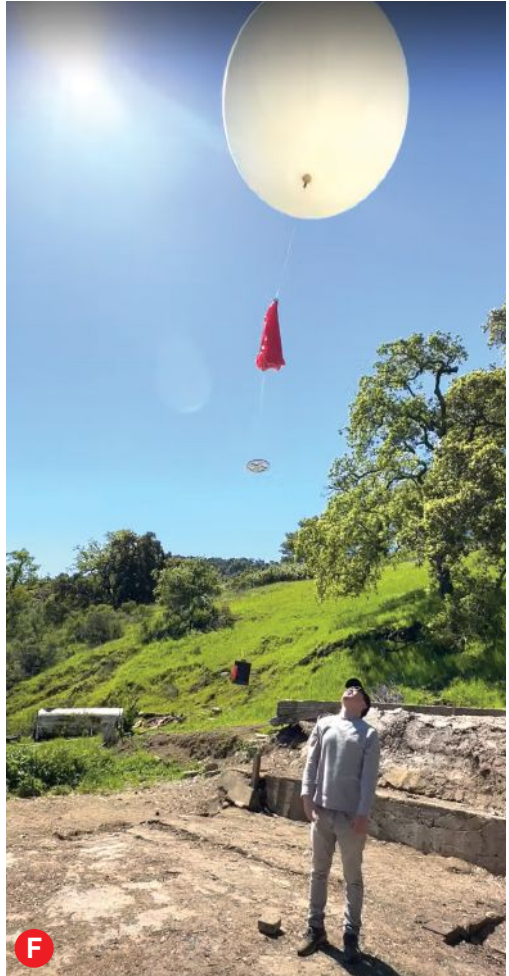
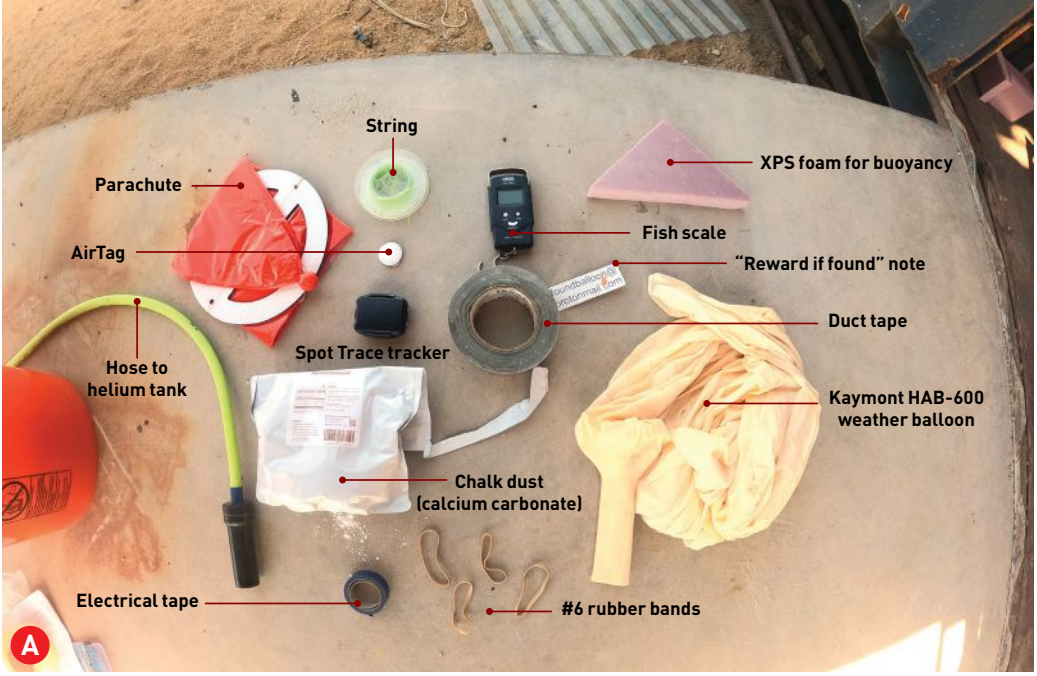
Only once have I had to chase a neutrally buoyant payload down the road!

### 5. CLOSE BALLOON

Tie it off with rubber bands and electrical tape (Figure E) and attach the payload if you have one. Bowlines are a great knot for this, and there's a detailed guide at [highaltitudescience.com/pages/tying-off-a-weather-balloon](http://highaltitudescience.com/pages/tying-off-a-weather-balloon).

### 6. LAUNCH!

Letting a balloon go (Figure F) is even more fun when it's fighting global warming. :)



## FEATURES: DIY Geoengineering / DIY Tornado Chasers

### 7. TRACK

Your Spot Trace tracker should update you on Spot's website as your balloon ascends and descends (Figure G). If you want to start heading to the likely destination, calculate your ascent rate based on your first several altitude and time readings from Spot and plug these into Sondehub. Descents vary, but 5m/sec has served as a good rule of thumb for us.

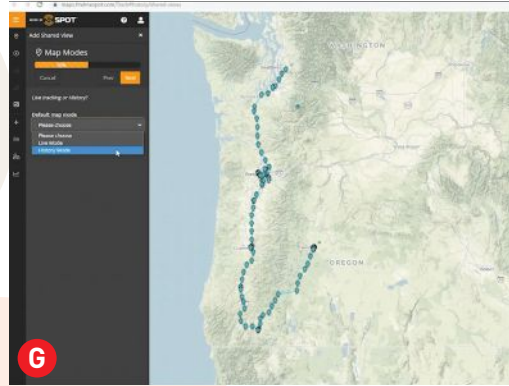
### 8. RECOVER

Put your AirTag in Lost Mode, head to wherever your last satellite beacon reading is, and try to get your payload back. Don't be afraid to ask. From "Don't Tread on Me" mountain homesteads to Air Force bases, nobody has said no to us recovering our balloon's payloads. Everyone loves balloons!

### GOING FURTHER

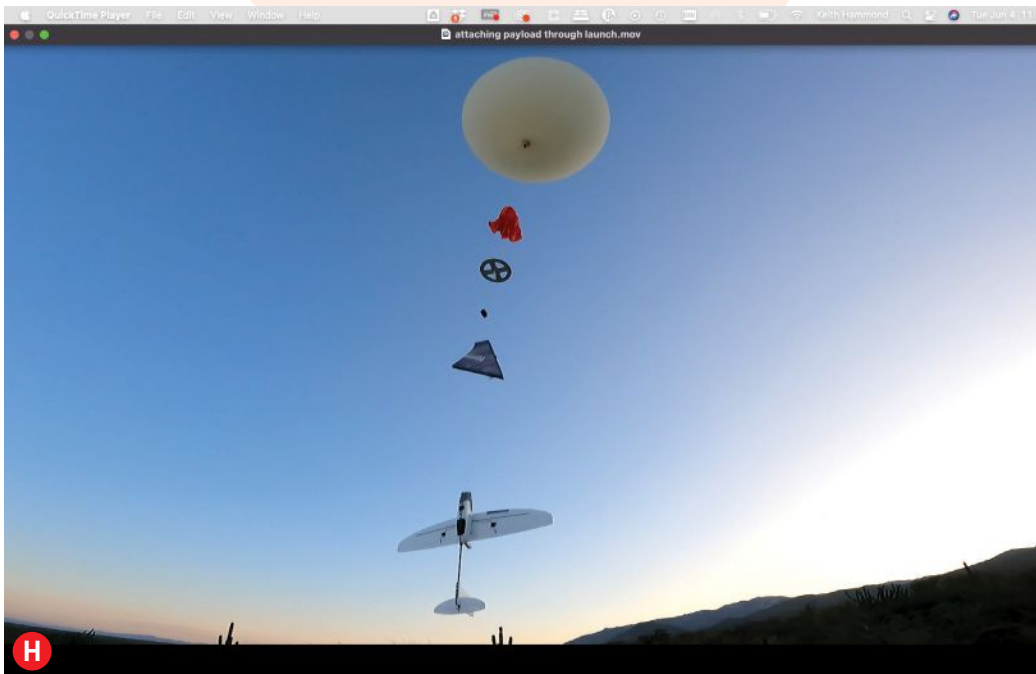
After you've gotten good at launching and tracking, here are some challenges you might tackle:

- Making your own hydrogen via electrolysis
- Compressing some of the balloon to control altitude during flight
- Burning sulfur at altitude to produce sulfur dioxide directly in the stratosphere



- Getting your payload to glide back to you (Figure H) on an Ardupilot-controlled RC plane ([ardupilot.org](http://ardupilot.org)) or GPS-guided parachute ([makezine.com/go/auto-return-parachute](http://makezine.com/go/auto-return-parachute)).

If you launch, please let me know how it goes at [makesunsets.com/pages/contact](http://makesunsets.com/pages/contact). We've learned a lot from other makers about how to get to the stratosphere, and we've got a lot more to learn. Since the Industrial Revolution, humankind has geengineered a warmer planet with our carbon emissions from burning fossil fuels. Now it's up to makers to cool Earth! 🌍



Make Sunsets