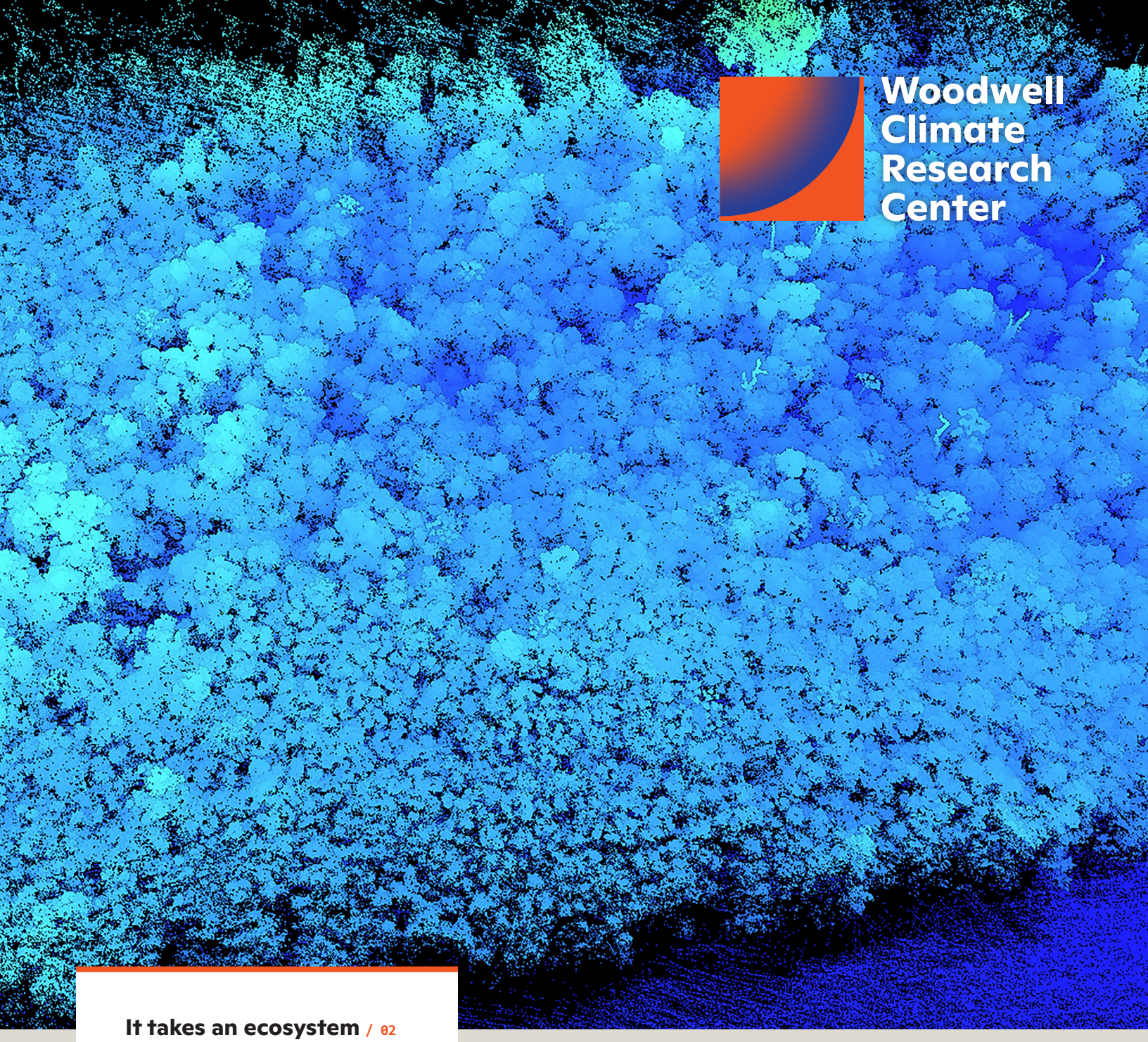

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Month in Review • February 2025
woodwellclimate.org

It takes an ecosystem

A special message of resolve from President and CEO Dr. R. Max Holmes

We spend a lot of time telling you how unique, and uniquely important, our work here at Woodwell Climate is. With good reason. I can't think of a more important mission than science for solutions to address the climate crisis, and our partnership model and focus on impact distinguish us from many other scientific organizations.

But we are far from alone in working to advance scientific understanding of our planet and propel us toward a healthy, equitable, sustainable future (thank goodness). This is work that takes a rich ecosystem of actors each playing their part, from corporations to non-profits, academic institutions to federal agencies. Those federal agencies have been prominent in our thoughts and conversations, as well as headlines, in recent weeks.

NASA, NOAA, NSF, USGS, EPA, USDA, NIH, DOE ... the list goes on. Not everyone knows what all these acronyms stand for, but collectively, these federal departments and agencies conduct essential research, provide tools beyond the capacity of any individual organization, and distribute tens of billions of dollars in research funding.

NASA and NOAA satellites are sources of essential—and freely available—data about how our own planet is changing.

Through the National Weather Service, the National Hurricane Center, the Climate Ready Nation initiative, and more, NOAA provides critically important science about weather, oceans, and climate, to help U.S. communities be safer and more successful.

The Department of Energy is home to the nation's seventeen national laboratories, which for decades have been flagships of innovation and discovery to "tackle the critical scientific challenges of our time."

The US Global Change Research Program, established in 1990, provides regular National Climate Assessments and coordinates activities across fifteen departments and agencies to enable an all-of-government approach to addressing a changing environment.

Woodwell Climate researchers benefit from federal grants, build on satellite and other federal datasets, collaborate with federal researchers, and participate in federally-coordinated research synthesis efforts. Federal scientists are friends and colleagues here in Woods Hole. Two of our former CEOs have served in the White House Office of Science and Technology Policy, one as the Director of that Office, and I served for two years at NSF as Director of the Arctic System Science Program. In other words, we are intimately familiar with the important work of our federal agencies, and the people who do it.

Soon after I arrived at NSF in 2013, I wrote the following in a newsletter "My dominant impression is one of respect for my new colleagues at NSF. They are all smart, hard working, and dedicated to funding the best science. They ... care deeply about scientific progress. They struggle, even agonize, about funding decisions and have to constantly weigh many competing priorities... But they keep at it, year after year, doing their absolute best to do the most with the resources they have."

As federal employees face unprecedented challenges, I want to express my heartfelt gratitude for all that they do. They are shining examples of public servants. They make our country stronger and our world a better place.

Onward,

Max

above: photos by Sarah Ruiz, Dustin John, Dee Sullivan/MinFin Photography, Kayla Mathes, Mitch Korolev, Eric Lee

‘3D pointillism’: LiDAR paints detailed pictures of field, forest, and carbon storage

This laser-based remote sensing technology is one of the most powerful tools we have for studying landscapes

Sarah Ruiz Science Writer and Editor

Despite thorough preparations, flying the drone is still nervewracking.

Dr. Manoela Machado, a Research Scientist at Woodwell Climate, has double- and triple- checked her calculated flight path over a study plot in the Cerrado, Brazil’s natural savanna. The drone can essentially fly itself, and she’ll be monitoring its speed, altitude, and battery life from her handheld controller on the ground, but many things could still go wrong. High winds, an unforeseen obstruction, loss of connectivity—all could jeopardize the mission, potentially dropping the expensive equipment 40 meters into the woodland canopy below.

Aboard Machado’s drone sits a powerful piece of technology—a LiDAR sensor. Developed originally for use in meteorology, this remote sensing technique now has widespread applications across scientific fields, from archaeology, to urban planning, to climate science. At Woodwell Climate, Machado and others employ LiDAR to create detailed three dimensional models of landscapes, which provide valuable insight into the structure of ecosystems and the amount of carbon stored in them—all with just a few (million) pulses of light.

What is LiDAR?

LiDAR stands for Light Detection and Ranging. Put simply, it is a sensor that uses laser light to measure distance.

Similar to other technologies like sonar and radar, which use sound and radio waves, respectively, LiDAR is an example of an “active” sensor. “Passive” sensors like cameras collect ambient light, while LiDAR actively pings the environment with beams of laser light and records the time those beams take to bounce back. The longer the return time, the further away an object is. That distance measurement is then used to calculate the precise location in three-dimensional space for each reflection.

This process is repeated millions of times during a single scan, resulting in a dense cloud of point locations. With some advanced computing, the data can be assembled into a 3D picture of the landscape.

“It’s effectively three dimensional pointillism,” says Woodwell Climate Chief Scientific Officer, Dr. Wayne Walker, who has been using LiDAR in his studies for 25 years.

Far more detailed than an oil painting however, a LiDAR model can reconstruct nearly every leaf, twig, and anthill on a landscape.

“Once you construct that cloud of millions of points, you get to walk inside the forest again,” says Machado. “When you finish processing the data and see the cloud you go, ‘I remember that tree! I remember standing there!’ It’s mesmerizing.”

For a project like Machado’s, scanning a few dozen hectares, the sensor is usually placed on a drone. Larger study areas require sensors mounted on low-flying airplanes or even satellites, but for small ground-based applications there are sensors one can carry, mount on a tripod, or attach to a backpack. Some newer phone models even have LIDAR apps built in. Regardless of how LIDAR is deployed, it remains a straightforward method of data collection. Just point the sensor at what you want to scan and within minutes, you’ve captured the data for a detailed three-dimensional model of your area of interest.

Estimating the weight of a forest

What Machado and Walker are often after from a LiDAR scan is a measurement of biomass, or the total weight of the organic matter present in an ecosystem. Plants store carbon in the form of organic matter, so biomass measurements are an easy way to estimate an area’s carbon storage.

However, measuring a forest’s biomass directly would require cutting down all the trees, drying them out, and weighing what’s left—impractical and needlessly destructive—so scientists use proxy measurements. Walker likens the process to trying to estimate the weight of a human without access to a scale.

“What are the measurements you might use if you couldn't actually physically measure weight? You might record height, waist size, inseam, and if you obtain enough of these measurements you can start to build a model that relates them

above: LiDAR scan image of a forest-cropland edge at Tanguro Research Station in Brazil. / imagery by Manoela Machado

to weight," says Walker. "That's what we're trying to do when we estimate the biomass of an entire forest."

Raw LiDAR data is only a measurement of distance, but by classifying each point based on its location relative to the cloud, researchers are able to extract the proxy measurements needed to model biomass across the ecosystem. Before LiDAR, these proxy measurements— things like trunk diameter, height, and tree species—had to be recorded entirely by hand, which limits data collection based on human time and resources. The time-saving addition of LiDAR has vastly expanded the possible scale of study plots. While field measurements are still essential to calibrate models, LiDAR is one of the only technologies that can give scientists enough detail and scope to assess carbon stocks over entire ecosystems.

"There is no other kind of sensor that even comes close to LiDAR," says Walker.

The power and potential of LiDAR

At Woodwell Climate, researchers have employed the power of LiDAR to map biomass and carbon from Brazilian forests, to the Arctic tundra. Outside of the Center, the technology has found applications in archaeological surveys, lane detection for self-driving cars, and topographical mapping down to a resolution of half a meter.

But the detail that makes LiDAR so powerful can also make the data a challenge to work with. A single scan produces millions of data points. According to Geospatial Analyst and Research Associate, Emily Sturdivant, who analyzed LiDAR data for Woodwell's Climate Smart Martha's Vineyard project, that wealth of data often overwhelms our ability to extract the full potential of information available in one point cloud.

"LiDAR creates so much data that when you look at it, it's hard not to be blown away imagining all the different things you could do with it. But then reality kicks in," says Sturdivant. "It's challenging to take full advantage of all those points with our current processing power. It's a matter of the analysis technology catching up with the data."

Processing LiDAR data requires large amounts of computing time and storage space, especially when performing more complex analyses like segmenting the data on the scale of individual trees. As machine learning and cloud computing technologies advance however, this becomes less of an obstacle, and the potential insights from LiDAR datasets will advance along with them.

LiDAR can be an expensive endeavor, too. Drones with the right equipment can cost tens of thousands of dollars, as can hiring a plane and pilot and paying for jet fuel, so data sharing has been important in making the method more cost effective. U.S. government agencies like NASA and the USGS have facilitated the collection of LiDAR data through satellites and plane flights, making the data available for public use. Woodwell Climate research has benefitted from these public datasets, using them to inform landscape studies and carbon flux models.

According to Sturdivant, the reliable production of public data has been greatly beneficial to advancing LiDAR-based studies, though it now faces risks from federal cuts to science agency funding.

"One of the greatest advantages of having publicly supported data is the consistency, but that's exactly what's now at risk," says Sturdivant. "Public accessibility has been so important in allowing new scientists to learn and experiment and then help everyone else learn."

Each new LiDAR scan represents a trove of information that could be used to better understand our changing planet, making it critical to continue supporting and collecting LiDAR data. Its intensely visual and highly detailed nature has made it one of the most powerful tools we have for understanding something as complex as a forest.

"And on top of that," says Machado "It's just visually beautiful."

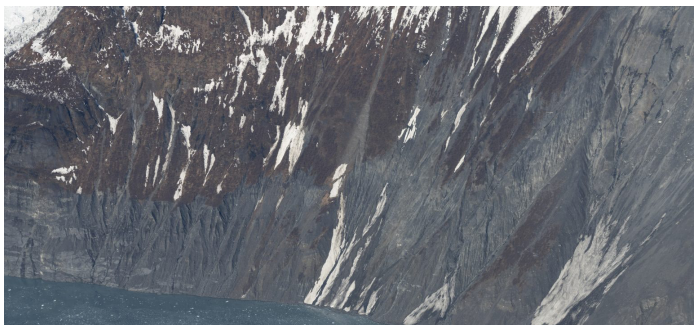
above: Machado checks drone equipment pre-flight. / photo by Carlos Ferreira

From translating data into tools, to improving hazard management

Fund for Climate Solutions awards five new grants.

Maggie Lin Communications Manager

The first round of 2025 Fund for Climate Solutions (FCS) awardees has been announced. The FCS advances innovative, solutions-oriented climate science through a competitive, internal, and cross-disciplinary funding process. Generous donor support has enabled us to raise more than $10 million towards the FCS, funding 74 research grants since 2018. Many of the latest cohort of grantees are translating data into tools for amplified impact. One project is bringing climate-related hazard expertise to at-risk communities, empowering them to co-create hazard management plans with their government officials.



Climate and Indigenous-centered boreal wildfire risk assessment

LEAD: DR. KAYLA MATHES
COLLABORATORS: DR. BRENDAN ROGERS AND DR. PETER FRUMHOFF

While fire has always been an important part of boreal ecosystems, fires that reach beyond historical patterns on the landscape are posing widespread consequences for climate, Indigenous sovereignty, and public health. Through our partner Woodwell Climate researchers have identified two key barriers to responsive management and policy action: 1) Fire managers currently lack maps that identify areas with both a high probability of wildfire, and a high carbon emission potential from burning and permafrost thaw. 2) Current fire management priorities do not adequately include Indigenous knowledge and community needs. This project will **generate two maps to address boreal fire management knowledge gaps**. The team will create one map representing wildfire carbon vulnerability, and will also work with Yukon Flats Indigenous communities to co-produce a regionally-specific map that identifies their wildfire management needs and priorities.

Landslide hazard management workshops in Homer and Seward, Alaska

LEAD: DR. ANNA LILJEDAHL
COLLABORATOR: DR. JENNIFER FRANCIS

Extreme rain events, glacier retreat, and permafrost thaw are making landslides and landslide-generated tsunamis in Alaska more likely. However, these hazards are not well-integrated into land and emergency management—for example, warning systems are relatively non-existent. The project team **will host workshops in two Alaska communities at risk** for landslides and landslide-generated tsunamis to raise awareness about the threats among residents and public agencies, and to identify landslide hazard management practices. The workshops will bring together experts in science and hazard mitigation; city, borough, and state officials; and community members to jointly develop recommendations for action. This effort builds on the ongoing work of Dr. Liljedahl's project, Arctic Tsunamigenic Slope Instabilities Partnership (Arctic T-SLIP), and will support a future group of research proposals to the National Science Foundation on landslides and landslide-generated tsunami hazards. Insights gained from these workshops will also add detail to a Woodwell Climate Just Access risk report completed for Homer in 2021.

left: Yukon Flats National Wildlife Refuge. / photo by Kayla Mathes
right: Vulnerable slope of Alaska's Barry Arm. / photo by Chris Zimmerman, USGS

Forms and functions of soil organic carbon

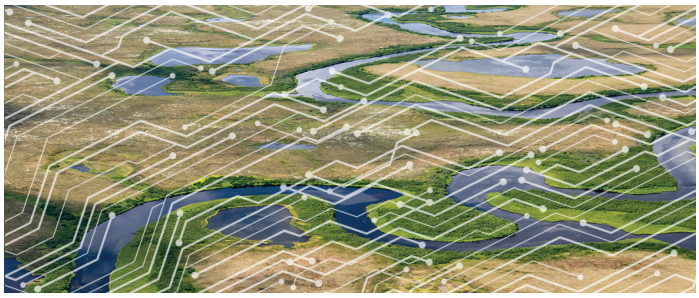
LEAD: DR. JONATHAN SANDERMAN
COLLABORATORS: DR. JOSÉ LUCAS SAFANELLI, DR. LUDMILA RATTIS, DR. CHRISTOPHER NEILL

Not all carbon is created equal—some forms of carbon are easier for microbes to break down, while others are more persistent. In soils, scientists are typically interested in a few specific forms of organic carbon, but each type has a different decay rate. Measuring the amount of each type of carbon—referred to as fractions—in a soil sample is currently labor intensive, sometimes requiring highly specialized equipment. Woodwell Climate researchers recently proved that a 60-second, low-cost spectroscopy scan can provide similar information on soil carbon fractions to days of work with traditional methods. However, this scan relies on machine learning or deep learning algorithms and high-quality, geographically appropriate training datasets. This project will **build an open-source database of soil carbon fraction data, along with freely-available models** to predict soil carbon fractions using spectroscopy, hosted by the Woodwell-led Open Soil Spectral Library and Estimation Service. This groundbreaking solution offers a transformative approach to soil carbon monitoring—making soil carbon fraction prediction more widely accessible to labs around the world and changing the game for land management.

Empowering the Tropical Forests Forever Facility with a tool for informed decision-making

LEAD: DR. GLENN BUSH
COLLABORATORS: KATHLEEN SAVAGE, PATRICK FEDOR, EMILY STURDIVANT, DR. WAYNE WALKER, DR. LUDMILA RATTIS, DR. MICHAEL COE

The Tropical Forests Forever Facility (TFFF), is an initiative spearheaded by the Government of Brazil to establish a US$125 billion global investment fund. If successfully established, TFFF can generate long-term finance to provide ongoing annual compensation to tropical forest nations to conserve intact tropical forests. The fund now needs to build confidence amongst potential sponsors to demonstrate feasible pathways to impact. The project team will **create a new location-based dataset of cost-effective forest conservation options** for the Democratic Republic of Congo (DRC) and Brazil, where Woodwell researchers have a long history of relationships and expertise. This dataset will provide valuable information around what forest conservation strategies will be effective, and where, based on financial and social benefits to people in the target landscapes. Ultimately, the team will be able to concretely identify how much forest conservation can be achieved with a given budget, and where to target efforts to resolve the highest-priority risks. With this information, the TFFF can demonstrate the effectiveness of the program and incentivize participation of sponsor countries and tropical forest nations.



A generic climate AI framework for multi-domain time series prediction lead

LEAD: DR. YILI YANG
COLLABORATORS: DR. ELCHIN JAFAROV, DR. BRENDAN ROGERS, DOGUKAN TEBER, DR. JOSÉ LUCAS SAFANELLI, DR. ANDREA CASTANHO, DR. CHRISTOPHER SCHWALM, DOMINICK DUSSEAU, DR. MARCIA MACEDO, DR. JONATHAN SANDERMAN, DR. ANNA LILJEDAHL, DR. SUE NATALI, DR. MICHAEL COE

Current climate science relies heavily on physics-based numerical models to make a wide range of predictions—from thawing permafrost in the Arctic, to tropical fires in the Brazilian Amazon, to soil carbon budgets of pastures, and risks associated with flooding. These types of models require an intense amount of computing power, and are expensive to run enough times to test a variety of detailed scenarios and assumptions. Researchers often need to simplify the models or the questions they are asking, limiting the insights that they can extract. To address this problem, the project team will use deep learning to **develop a Center-wide AI framework for climate data** that encompasses data from across regions and projects, reducing computational costs and energy demands. This new framework will have the potential to transform the ability of all Woodwell Climate researchers to provide policymakers with rapid, accurate predictions that support urgent climate response strategies.

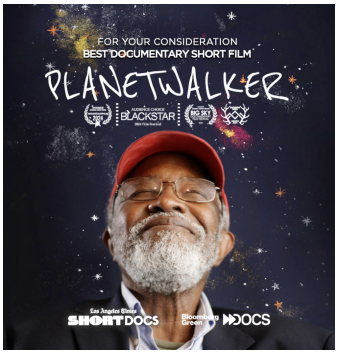
left: (top) Screenshot from explorer.soilspectroscopy.org; (bottom) A pocket of deforestation in the Amazon. / photo by Paul Brando
right: Arctic tundra landscape overlaid with computer network imagery. / photo by Chris Linder

Kaj Lynöe, Dani Trangmoe, and Patrick Murphy prep eddy covariance tower equipment for field placement later in the spring. / photo by Kecy Kent

WOODWELL CLIMATE CONVERSATIONS SERIES

Planetwalker

Documentary screening and Q & A with John Francis



After witnessing a devastating oil spill, John Francis takes a vow of silence and gives up motorized transport, embarking on a 17-year journey across the U.S. to raise awareness about environmental issues, armed only with a banjo and his principles.

Learn more and register at: woodwellclimate.org/planetwalker

In the news: highlights

Eos spotlighted research that describes how Alaska lakes and ponds reveal the effects of permafrost thaw, to which Dr. Jennifer Watts and Andrew Mullen contributed.

Yale Climate Connections interviewed Dr. Jen Francis for a story explaining how U.S. winter weather is changing in a warming world.

The Enterprise promoted an upcoming event hosted by the Coonamessett River Trust at the Falmouth Main Library, where Dr. Zhongqi Chen will be presenting on the FishEye project.

Bloomberg quoted Dr. Jen Francis on the importance of NOAA's services in an article covering the recent disruptions at the agency.

WATCH Dr. Foster Brown was interviewed on two broadcasts this past week, speaking about extreme heat—with *TV Globo's JAC1* and with *TV Norte Acre* (13:43, Portuguese).

Maps.com published an article praising a map by Christina Shintani and Greg Fiske, Forest Carbon of the United States.

The Max Planck Institute for Biogeochemistry published a press release covering new research on the current state of the Arctic carbon cycle, which Dr. Scott Zolkos contributed to.

Media attention on the research that revealed the Arctic's changing carbon balance continues: *Mongabay* quoted Dr. Sue Natali on the study, and *Popular Mechanics* quoted both Natali and Dr. Anna Virkkala.

Mongabay quoted Dr. Jen Francis on how ocean heat waves are outweighing La Niña's cooling effects. She was also quoted by *Howard University News Service* on how heavy rainfall followed by dry conditions contributed to the severity of wildfires in California.

Dr. Rich Birdsey was quoted by *Science Insider*, commenting on the lack of guardrails in the federal plan for protecting old-growth forests—a plan which ultimately never made it to the final stage.

Cabin Radio interviewed Dr. Brendan Rogers about protecting the carbon in Canada's Northwest Territories, in advance of his presentation at the Landscape Carbon Workshop in Yellowknife.

The Washington Post interviewed Dr. Jen Francis for a story about the links between Arctic warming, weakening northern weather systems, and extreme cold. The story was featured in the "Post Most" email newsletter.

Francis was also quoted in an *Al Araby Al Jadeed* story, providing insights into the impacts of the United States' withdrawal from the Paris Agreement.

CBC interviewed Dr. Anna Virkkala about the research she led which shows the Canadian North is not as effective a carbon sink as once thought.

Drs. Anna Virkkala and Sue Natali spoke with *WBUR* about how a third of the Arctic is now a net greenhouse gas emitter.

cover: LiDAR scan image of a forest-cropland edge at Tanguro Research Station in Brazil. / image by Manoela Machado

Donations play an important role in securing the future of Woodwell Climate Research Center's work—and help safeguard the health of our planet for generations to come.

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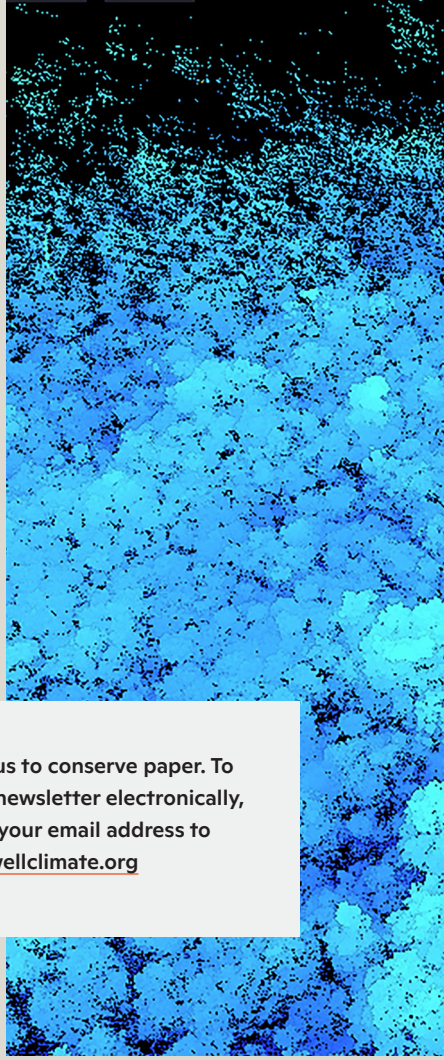

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